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## CONDITION SURVEY OF CEDARS LOCK AND DAM LOWER FOX RIVER, WISCONSIN

by

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June 1982 Final Report

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Prepared for U. S. Army Engineer District, Chicago Chicago, Ill. 60804

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A condition survey was performed at Cedars Lock and Dam on the Lower Fox River, Wisconsin. 'The field investigation included drilling for core samples of concrete, foundation rock, and backfill. Selected specimens of these materials were tested in the laboratory for certain physical and mechanical properties. Results of the field investigation and laboratory tests indicated that the concrete in the lock and dam is locally cracked and lightly deteriorated but structurally sound.

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20. ABSTRACT (Continued)	
Rock masonry in the lock appears sound even though the outside surface is weathered. Cycles of freezing and thawing have caused the deterioration. lock and dam is founded on competent bedrock. No soft or otherwise weak were detected in the bedrock. Soundings should be made to detect any scot behind the dam. It is suggested that the reinforcing steel in the tainterpiers, adjacent to the hinge pins, be examined for corrosion.	The zones uring

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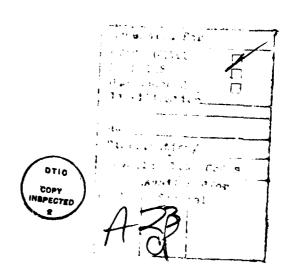
#### **PREFACE**

The investigation described herein was performed for the U. S. Army Engineer District, Chicago, by the U. S. Army Engineer Waterways Experiment Station (WES). The work was authorized by DA Form 2544, No. NCC-IA-80-57, dated 19 March 1980.

The testing program was accomplished under the direction of Mr. Bryant Mather, Chief of the Structures Laboratory (SL), WES, and Mr. John M. Scanlon, Jr., Chief of the Concrete Technology Division (CTD), SL. The core drilling was conducted by the Geotechnical Laboratory (GL), WES, under the direction of Mr. Mark A. Vispi. Laboratory work in the CTD was done with the assistance of Mr. F. S. Stewart and Mrs. Joyce C. Ahlvin. Mr. R. L. Stowe was Project Leader for the investigation. Mr. Stowe and Mrs. Ahlvin prepared this report.

Funds for publication of the report were provided from those made available for operation of the Concrete Technology Information Analysis Center (CTIAC). This is CTIAC Report No. 52.

Commanders and Directors of WES during the conduct of the investigation and the publication of this report were COL N. P. Conover, CE, and COL T. C. Creel, CE. Technical Director was Mr. F. R. Brown.



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# CONVERSION FACTORS, INCH-POUND TO METRIC (SI) UNITS OF MEASUREMENT

Inch-pound units of measurement used in this report can be converted to metric (SI) units as follows:

Multiply	Ву	To Obtain
feet	0.3048	metres
feet per second	0.3048	metres per second
inches	0.0254	metres
miles (U. S. statute)	1.609347	kilometres
pounds (force) per square inch	0.006894757	megapascals
pounds (mass) per cubic foot	16.01846	kilograms per cubic metre
tons (force) per square foot	0.09576052	megapascals

# CONDITION SURVEY OF CEDARS LOCK AND DAM LOWER FOX RIVER, WISCONSIN

#### PART I: INTRODUCTION

#### Project Description

1. The following general description of the Cedars Lock and Dam is taken from Reference 1.

"The headwaters of the Fox River rise in Columbia County, Wisconsin, and flow in a Northeasterly direction for about 176 miles into Green Bay. The section of the river from Lake Winnebago to Green Bay is generally referred to as the Lower Fox River and is 39 miles long. It has a change in gradient of about 168 feet; channel widths are generally 500 to 1000 feet and minimum channel depths are 9.6 feet below Depere Lock and 6 feet below Menasha Lock. Typer pool E1. 698.66 and lower pool E1. 688.88 are referred to mean water level at Fathers Point, Quebec I.G.L.D. (1955) (Interntaional Great Lakes Datum)."

- 2. The Cedars lock is of masonry design and founded directly on dolomite. It has usable lock dimensions of 35 by 144 ft;\* the lift is 9.8 ft at normal river stage.
- 3. The Cedars dam is of concrete gravity wall design and is keyed into the dolomite foundation. The dam consists of a 263.3-ft long spillway on the right side of the dam and a 211.0-ft long spillway on the left side of the dam. The midsection of the dam is a 180.0-ft long sluiceway containing seven tainter gates. Crest elevation\*\* of the spillway sections is 698.66 (IGLD 1955); for prior datum planes, add 1.75 ft.

#### Location of Study Area

4. The Cedars Lock and Dam is located approximately 27.5 miles

<sup>\*</sup> A table of factors for converting inch-pound units of measurement to metric (SI) units is presented on page 3.

<sup>\*\*</sup> All elevations (el) cited herein are in feet referred to I.G.L.D. 1955 (International Great Lakes Datum).

from the mouth of the Fox River at Green Bay. The lock and dam is situated on the river between the towns of Little Chute and Kimberly. A general plan view of the site is given in Plate 1; this plate is duplicated from Reference 1.

#### Background

- 5. In March of 1980 the Waterways Experiment Station (WES) was requested by the U. S. Army Engineer District, Chicago (NCC for North Central Division, Chicago), to review a number of documents, References 1,2, and 3, and submit a proposal for a condition survey of Cedars Lock and Dam. Reference 3 contained a preliminary exploration and testing program which was used as guidance in developing the WES proposal. The amount of exploration and testing that could be accomplished was governed by available funding.
- 6. After the drilling was initiated, District technical staff increased the number of borings. The added borings were drilled and some of the funding allocated for laboratory testing and reporting was diverted to cover the increased drilling cost. The reasons for increasing the number of borings was twofold; first, additional foundation information would be obtained for developing geologic profiles. Secondly, by drilling additional borings with the on-site marine floating plant, crane, etc., cost of mobilization and demobilization would not be incurred for a second drilling effort. The bedrock core from these added borings is preserved at the WES in case further testing is required. It was decided not to drill the lock masonry for fear of creating leaks along the mortar joints.
- 7. Work on this project was initiated by the Chicago District prior to the 1980 realignment of North Central Division. Work continued under the direction of the Chicago District although the Detroit District is now responsible for the geographical area that includes the Lower Fox River.

#### **Objective**

8. The objectives of this study were to evaluate subsurface conditions, to assess the in-place concrete conditions, to ascertain selected physical properties of concrete and rock, and to evaluate this information in order that design parameters be presented as guidance for a structural stability analysis. In addition, selected physical properties of backfill materials are to be determined. The Detroit District is scheduled to perform the stability analysis.

#### Scope

9. The report discusses the drilling effort involved in obtaining samples of soil, concrete, and rock. The physical condition of the inplace exposed concrete is described using a limited amount of information Selected physical properties of the core samples were determined using standard Corps of Engineers test methods. A limited number of borings were drilled behind the sluiceway dam section for purposes of detecting possible covered scouring. A study was made to consolidate and evaluate engineering information, geologic and boring data, and laboratory test data as they relate to the foundation condition. Available construction and engineering data records were reviewed.

#### PART II: PRELIMINARY STUDY

#### Review of Records and Drawings

- 10. The author made a visit to the Kaukauna Project Office to review available engineering and construction drawings in the hope of finding foundation information. Very little information was available. Construction drawings, records, and photographs do not provide much information about the foundation condition. The drawings and photographs indicated that the lock and dam was founded on "nearly horizontal limestone rock."
- 11. Right-of-way fly-over photographs of the Lower Fox River were studied for indications of geologic structures such as joint systems and faults. The photographs were helpful in showing the plate-like bedding near the lock and dam. No indications of faulting were detected in the photographs or on topographic maps of the area. To the Kaukauna Project Engineer's knowledge, scour profiles had not been taken at Cedars Lock and Dam; in addition, scour holes behind the dam had not been detected.

#### Inspection of Lock and Dam

12. The author and Mr. Steve Running of the Raukauna Project Office made an inspection of the Cedars Lock and Dam site. The main purpose of the inspection was to determine if macroscopic misalignment, settlement, expansion, or contraction of the concrete and masonry structures could be detected. The lock backfill was observed for settlement. The surface condition of the concrete was observed and boring locations assigned.

#### Lock chamber walls

13. No misalignment, settlement, or contraction of the masonry walls was detected. Expansion of the masonry occurred at exposed edges of some of the rock blocks, the expanded portions of the blocks being adjacent to block joints. This expansion is not viewed as a problem.

The top of the lock walls has been resurfaced with concrete and is in good condition. The lock masonry walls appear structurally sound and should function for a long time as originally intended. The stairways at the downstream end of the lock are in poor condition.

#### Lock embankment

14. The grassed embankment adjacent to both lock walls appears in good condition. The grassed area between the toe of the embankment against the riverside lock wall and the river shows a little differential settlement in the order of 6 to 10 in. The lockmaster said that small holes occasionally developed in the area and that the ground becomes spongy to walk on. He did not specify what conditions prevailed when the ground was spongy. Photographs No. 1 through 8 (see Appendix A) show the general condition of the lock walls and the embankment.

# Dam, left abutment wall, and spillway

- 15. Photographs 9 and 10 show the frost damaged concrete in the left abutment wall. There was no evidence of misalignment, settlement, or contraction in the dam sections. Slight expansion of local areas exists in the concrete due to the results of freezing and thawing action. Dam, left spillway
- 16. The concrete in the foot bridge piers appears in good condition. See Photograph 11.

#### Dam, sluiceway

- 17. The condition of the concrete in the sluiceway piers is generally good (see Photographs 12 through 15). Damage due to freezing and thawing is confined to local areas. Minor amounts of concrete in the piers at low pool elevation have been abraded by water and ice action. Cracking through the piers near the gage hinge piers is present in each pier. Some piers are cracked through near the steps. The Chicago District conducted an analysis of the cracked concrete piers and determined that reinforcement within the piers was effective for gate loads; see Reference 1, Appendix B, page 13.
- 18. It is suggested that a study be made to determine if the reinforcing steel in the sluiceway piers is rusted. Infiltrating water along

the cracks could have caused reinforcement to rust. The concrete from around the downstream side of the gate hinge pin could be excavated to examine the reinforcing steel.

#### Dam, right abutment wall

- 19. The concrete in the right abutment wall is in good condition. A diagonal crack exists in the upstream portion of the wall and a near vertical crack exists in the downstream portion of the wall. The cracks appear to go through the wall. See Photographs 16 through 18.
- 20. During the inspection trip a visit was made to a quarry about 1/4 mile from the Lower Fox River. The rock here is believed to belong to the same formation (Galena-Platteville Dolomite) that exists beneath the Cedars Lock and Dam. Photographs 21 and 22 give a general and close-up view, respectively, of the quarry rock. The quarry floor and benches are bedding planes which are nearly horizontal.
- 21. Photographs 21 and 22 were taken in the dry dock area at the Kaukauna Project Office. A gate wall is seen founded on the bedrock.

#### PART III: FOUNDATION EXPLORATION

#### Previous Exploration

22. Presumably borings were taken prior to construction in the early 1930's. However, no information derived from such borings was available for review.

#### Current Drilling

- 23. Drilling equipment consisted of an Acker Toredo Mark II and a Sprage and Henwood skid-mounted rotary drill rig. A Diamond Core Drill Manufacturers Association standard 4-in. by 5-1/2-in. double tube swivel tube core barrel was used with diamond bits to obtain the concrete and bedrock core. Access to the drill holes was by a marine floating plant and for holes on top of structures by crane. Floating plant was supplied by Kaukauna Project Office. Continuous samples were obtained in all borings. Appropriate size casing was set in the bedrock when necessary to keep a boring open. A Concord portable drill rig was used in drilling horizontal cores.
- 24. The boring location plan is presented in Plate 2. A summary of boring information is given in Table 1; presented is the type boring, the location by structure, the elevation of the top of boring, the elevation top of rock, the elevation bottom of rock, and the date when the boring was started. The number of borings and boring locations were determined through mutual agreement by the Chicago District and the WES technical staff. Specific boring locations at the lock and dam were assigned by Mr. Stowe of the WES.
- 25. Two borings were put through the backfill and into bedrock; one boring was drilled on either side of the lock walls. Bedrock was sampled to a depth of 5.1 ft in the landside boring and to a depth of 26.7 ft in the riverside boring. A piezometer was installed in the riverside boring (C WES E1-80). It was set at el 682.2 (piezometer tip). Pertinent piezometer data were presented in Plate 3. Piezometer readings

were not taken by the WES drill crew. The deeper borings into bedrock were carried from 21 to 29 ft deep. The shorter scour borings were taken about 6 ft into rock.

- 26. Boring C WES D2-80 was left open while the drill crew remained on site. Water level readings were taken by the lockmaster for a short period of time. The water level readings are presented in Table 2.
- 27. Total footage drilled was 36.0, 68.75, and 157.5 ft, respectively, for soil, concrete, and bedrock. All soil, concrete, and bedrock was preserved for possible laboratory testing, the exception being the highly fractured, broken samples. Procedures for preserving and handling the samples are present in References 4 and 5. Color photographs of the core are presented in Exhibit A. Field drilling logs are presented in Appendix B.
- 28. Core recovery was good in all borings indicating the general good condition of the materials drilled at the lock and dam sites; core recovery averaged 98.4 percent. Drilling water loss was very small and restricted to several locations. In boring D3 at el 681.8 to 682.4 water loss occurred. This zone was bounded by shale seams with black surface staining.

#### Scour Detection

- 29. Scour borings were located behind the sluiceway dam section. It was felt that this section of the dam would likely contain covered scour areas if any exist. The four borings behind the sluiceway section did not reveal any covered scour areas; no evidence of displaced or recently (postdam construction) disoriented rock blocks was found.
- 30. Because of the limited number of borings drilled behind the dam and the fact that scour profiles have not been taken, scouring of the bedrock behind the dam could exist. It is suggested that scour profiles be made. Undercutting of the toe of the dam should likewise be studied.

#### PART IV: GEOLOGICAL CHARACTERISTICS

#### Geomorphology

- 31. Cedars Lock and Dam is located in Outagamie County, Wisconsin, in the lowland between Green Bay and Lake Winnebago. This geographic province of Wisconsin is termed the Eastern Ridges and Lowlands and covers an area of 21,000 square miles, including the 7,500 square miles under Green Bay and Lake Michigan. It is bounded on the east by the lowland of Devonian shale now submerged beneath Lake Michigan and on the north by Green Bay. The western border is found along the contact of the Cambrian sandstone with the lower Magnesian limestone from the Menominee River (Marinette County) to the Wisconsin River (Sauk and Columbia Counties). On the south the region is delineated by the terminal moraine at the edge of the most recent drift sheet and the Rock River below Jonesville.
- 32. Once much smaller than at present, the Lower Fox River valley was carved to its present size by the glacier. The immense ice sheet advanced southward cutting out the valley of Lake Michigan, while a tongue cut Green Bay Valley to its present dimensions. A medial moraine, the Kettle Range, was formed on the peninsula between Green Bay and Lake Michigan.
- 33. The retreat of the glacier, coupled with its cutting action, created a depression at Green Bay. The valley floor rises steeply with Lake Winnebago being 166.7 ft above Green Bay. This caused the Wolf and Upper Fox Rivers to change course and flow into the newly formed valley. Evidence of this can be seen in studies of the ancient shore of Lake Michigan by tracing red clay deposits. Lake Winnebago formed more recently by the deposition of glacial drift in the valley.
- 34. The western slope of the Upper Fox River valley is gentle, while the eastern slope is quite steep. Cliffs on the east are cut through the Cincinnati shales and Niagara dolomite and extend from Green Bay south past Lake Winnebago. The bedrock at the dam is the

Galena-Platteville dolomite of Ordovician age. All field boring logs identify bedrock as limestone; subsequent petrographic examination shows the bedrock to be dolomite.

#### Backfill

35. The backfill on either side of the lock is considered as construction fill. Profiles of borings El and E2 are presented in Plate 4. The backfill consists of inorganic clays, gravelly clays, and sandy clays; beneath these fine-grained soils is a strata (about 2.5 ft) of coarse-grained soil in the SC group. Beneath the soils is a layer of dolomite cobbles and boulders mixed with clay. The dolomite bedrock underlays the fill. The rock symbols used in the profiles in Plate 4 are for limestone; the symbols should be for dolomite.

#### Bedrock Stratigraphy

- 36. The bedrock beneath Cedars Lock and Dam is of the Galena-Platteville formation of the Champlainian series of the Ordovician system. This formation is between 120 and 155 ft thick in this area, as reported by the Wisconsin Geological and Natural History Survey.
- 37. The dolomite is gray-green, fine to medium grained, dense, moderately hard to hard, shaley, and fossiliferous in places. Bedding is massive. Thin shale beds, laminae, and stringers are part of the rock fabric. The shale is gray-green and quite hard. The shale features range in thickness from 0.01 ft to 0.08 ft and occur continuously to a maximum of 0.5-ft separation. The shale occurs parallel to bedding.
- 38. There appear to be two types of bedding surfaces in the core; they are designated Types A and B. Type A is irregular with semirounded peaks and valleys. Peak to valley distances range from 1/4 to 1/2 in.; periods are about 2 in. Type A surfaces are tightly interlocked and are the predominant type of bedding surface. Type B is almost planar, yet gently undulating with a few short asperities and steps; Type B bedding surfaces are interlocked. The thin hard shale is found on both types of

surfaces. A few stylolites exist in the core. Core breaks occur along the shale features. No soft, weak seams of shale or clay were detected in the core samples.

39. The dolomite contained infrequent solution cavities up to 0.05-ft diameter. With one exception, the cavities were filled with calcite. The cavities occurred between el 680 and el 684 and el 662 and el 670. One cavity in core D2 was filled with pyrite (at el 680.6). Staining appears in four of the cores (D4, D3, D5, E1) between el 666 and 667 and in three cores (D2, D3, D4) between el 684 and 685. In core D5 staining occurs from el 676.0 to 676.81. The staining and solution activity indicates that water has moved along bedding planes.

#### Geologic Cross Sections

40. Three geologic cross sections were drawn; sections A-A', B-B', and C-C' (see Plate 2 for cross section locations). Section A-A' (see Plates 5, 6, and 7) was drawn parallel to the dam axis and includes borings D3, D8, D2, D7, and D1. Section B-B' (see Plate 8) was drawn perpendicular to the lock, and section C-C' (see Plate 9) was drawn perpendicular to the dam at about its midlength. Section B-B' contains borings E1 and E2, and section C-C' contains borings D4, D2, D6, and D5.

#### Structure

- 41. The main structural feature in the bedrock is the nearly horizontal bedding. Hard shale beds, laminae, and stringers occur throughout the bedrock. However, the shale features are intact and intimately joined to the dolomite and considered a part of the rock fabric and are not considered individual troublesome units. There is no geologic feature within the bedrock that can be traced between borings.
- 42. The contact between the concrete and the bedrock core is well bonded except in cores D6 and D2. A complete separation exists in core D6 with brown calcite deposits on both surfaces. The calcite deposit indicates solution activity at the concrete-bedrock interface. Shale

pieces are embedded in the concrete to a shallow depth. A small amount of bedrock was probably left during cleanup prior to placing concrete. Evidence of solution activity is present in boring D2, again at the contact. Solution activity is present in the dam bedrock; however, it is not considered a problem at this time due to its apparent limited extent.

43. The extent of jointing in the bedrock could not be determined with the limited work done during this study. A total of four fractures (joints) were observed in the core. One short (1-ft long) vertical fracture exists in boring D3 at a midpoint el 684.2. Three fractures inclined at 45 deg from the horizontal were observed, one each in boring E2, D1, and D4. Jointing appears not to be a problem at the lock and dam in terms of stability of the two structures.

#### PART V: TESTS, TEST RESULTS, AND DISCUSSION

#### Test Specimens and Test Procedures

#### Cores received

- 44. Disturbed and undisturbed soil samples were recovered from the two backfill borings. The undisturbed samples consist of 14 steel tubes; the disturbed samples consist of 15 jars and 3 bags. Two boxes contained core samples. Table 3 describes the drill hole number, sample number, type sample, sample depth, and the material description of the soil samples received at the WES.
- 45. In addition to the soil samples, concrete and rock samples from 11 borings were received at the WES. Shipment of the materials was by government motor freight. All samples were received in good condition, and no sample breakage was detected. Pertinent information concerning the concrete and rock samples is presented in Table 4. Selection of test specimens
- 46. Disturbed and undisturbed samples from borings E1-80 and E2-80 were examined and representative samples were chosen for general engineering type testing.
- 4/. A detailed visual examination of core was made in the laboratory to supplement the field boring logs and to assist in the selection of representative test specimens. Concrete specimens were selected for testing based upon physical condition of the concrete and depth in order to obtain representative properties throughout the structure.
- 48. Three concrete specimens were selected from boring D2; one at the top, middle, and bottom of the boring. Test specimen depths shown in the tables of test results represent the midsection of the test specimen; e.g., el 696.5 is the midpoint of a piece of core with top el being 697.0 and the bottom el being 696.0. Both 6-in. and 4-in.-diameter concrete cores were used for testing. Four-inch-diameter rock cores were tested.
- 49. An attempt was made to select test specimens to be representative of the bedrock in close proximity to the base of the structure. The

test assignment locations can be obtained from appropriate tables of test results as well as from appropriate geologic cross sections.

50. Test specimens were selected for testing concurrent with the detailed logging of core; the logging began the day core arrived at the laboratory. The test specimens were rewrapped and stored in a moist curing room until time for testing; the moist room is maintained at  $73.4 \pm 3$  F  $(23 \pm 1.7$  C).

#### Laboratory testing program

- 51. Soil samples. The testing of the soil samples consisted of the following.
  - a. Gradation Curve.
  - b. Atterberg Limits Testing.
  - $\underline{c}$ . Triaxial,  $\overline{R}$ .
  - d. Direct Shear.
- 52. Concrete cores. The testing program of the concrete cores consisted of the following tests on representative selected cores.
  - a. Unit Weight,  $\gamma$ .
  - $\underline{b}$ . Compression Wave Velocity,  $V_{p}$ .
  - c. Compressive Strength.
  - d. Water Content, w .
  - e. Elastic Moduli, E.
  - f. Poisson's Ratio, v.
- 53. Rock cores. The testing of the bedrock cores consisted of the following tests on representative selected cores. The tests are grouped under either characterization tests or engineering design tests.
  - a. Characterization tests.
    - (1) Effective (As Received) and Dry Unit Weight,  $\gamma_m$  and  $\gamma_d$  .
    - (2) Water Content, w.
    - (3) Compressive Strength,  $q_{11}$ .
  - b. Engineering design tests.
    - (1) Elastic Moduli, E.
    - (2) Poisson's Ratio, v.
    - (3) Triaxial Strength.

- (4) Direct Shear Strength.
  - (a) Concrete on rock, precut (residual).
  - (b) Intact (maximum).
  - (c) Rock on rock, precut (residual).
  - (d) Cross bed (maximum).

#### Test procedures

54. The soil testing was accomplished according to EM 1110-2-1906, Laboratory Soils Testing. The characterization properties tests and the engineering design properties tests were conducted in accordance with the appropriate test method tabulated below:

Property	Test Method
Characterization	
Effective Unit Weight (As Received), $\gamma_m$ Dry Unit Weight, $\gamma_d$ Water Content, w Compressional Wave Velocity, $V_p$ Compressive Strength, $q_u$	RTM 109-77*  RTM 109-77  RTM 106-77  RTM 110-77 (ASTM D 2845)  RTM 111-77 (ASTM D 2938)
Engineering Design  Elastic Modulus, E  Direct Shear Strength  Poisson's Ratio, v  Triaxial Strength	RTM 201-77 (ASTM D 2148) RTM 203-77 RTM 201-77 RTM 202-77

<sup>\*</sup> Reference 5.

55. For the compression and triaxial compression test, the specimens were cut with a diamond-blade saw and the cut surfaces were ground flat to 0.001 in.; specimens were checked for parallel ends and the perpendicularity of ends to the axis of the specimen. Electrical resistance strain-gages were used for strain measurements. Two each were used in the axial and horizontal directions. The modulus of elasticity and Poisson's ratio were computed from the strain measurements. Axial specimen load was applied with a 440,000-1bf capacity universal testing machine. Confining pressure during the triaxial tests was applied using an electro-hydraulic pump.

#### Soil Properties

- 56. All of the laboratory test data from soil samples are presented in Plates 10 through 18. The data consist of the following:
  - a. Boring E1-80.
    - (1) One Atterberg Limits, classification (sieve analysis).
    - (2) One R triaxial test.
    - (3) One direct shear test.
  - b. Boring E2-80.
    - Three Atterberg limits, classification (sieve analysis).
    - (2) One R triaxial test.

This report does not present an interpretation or recommended design parameters for the materials in the backfill because of various unknowns. We don't know what type of slope stability analysis will be used by the district, where the failure plane will be assumed within the backfill, and whether the bedrock will be incorporated in the analysis.

#### Concrete Test Results and Discussion

- 57. The following comments pertain to the condition of the concrete in the dam. These comments are the results of examination of the core recovered at the dam. The condition of the exposed concrete is discussed in Part II of this report. The concrete characterization and engineering design test results are presented in Table 5.
- 58. The concrete recovered from borings is nonair-entrained. It is light gray-brown, hard, dense, contains natural dolomite aggregate 1 in. in maximum size that is rounded to subangular. The concrete contains occasional entrapped air voids from 1/4 to 1/2 in. in size and is well consolidated. A few gravel pockets occur (honeycombed areas), but they do not affect the structural integrity of the concrete. Minor amounts of white reaction products were found throughout the concrete. The white reaction material probably resulted from alkali-silica reaction and is an alkali carbonate. At this time the concrete is not

adversely affected by the process producing the white reaction product, nor will it be in the near future. The concrete in the dam is structurally sound and should serve its intended purpose. The exceptions are those local areas where frost-damaged concrete exist.

- 59. The horizontal core recovered from boring D11 contains fractures throughout its 3-ft depth. The core was taken from the south side of sluiceway pier 3 about 1.5 ft downstream of the gate hinge pin. The factures could have occurred when the through cracks in the pier, near the gage hinge pin, developed. Some of the fractures are closed while some are open. The open fractures could be filled with a sealing agent to prevent water from penetrating the concrete.
- 60. The author believes that there is no reason to immediately repair the cracked or frost-damaged concrete in the dam. Repair of these damaged areas could be performed during regular maintenance periods.
- 61. The average physical properties of the concrete are tabulated below along with selected statistics. Stress versus strain curves are presented in Piate 19 for the three concrete specimens tested:

Test	Average Value	Standard Deviation	No. Specimens
Wet Unit Weight, pcf	153.4	0.7	3
Water Content, %	5.1	0.2	3
Compressional Wave Velocity, fps	17,240	544	3
Compressive Strength, psi	7,602	1480	3
Modulus of Elasticity, x 10 <sup>6</sup> psi	4.69	0.42	3
Poisson's ratio	0.20	0.06	3

62. The physical properties of the concrete are characteristic of good quality concrete. The standard deviations are considered small and indicative of uniform concrete properties.

#### Rock Test Results and Discussion

63. The results of the characterization properties tests are presented in Table 4 for the bedrock. Stress versus strain curves are

presented in Plates 20 and 21. The following tabulation presents a summary of the average characterization properties and selected statistics for the bedrock.

Test	Average Value	Standard Deviation	No. Specimens
Effective Unit Weight, pcf	171.1	0.9	6
Dry Unit Weight, pcf	169.9	0.9	6
Water Content, %	0.7	0.2	6
Compressional Wave Velocity, fps	20,040	636	6
Compressive Strength, psi	20,050	2322	6
Modulus of Elasticity, $x 10^6$ psi	7.35	1.40	6
Poisson's Ratio	0.28	0.06	6
Shear Modulus, x 10 <sup>6</sup> psi*	2.87		6

<sup>\*</sup> Calculated using E and v.

64. The tabulated rock properties are reasonable for the high quality bedrock beneath the Cedars Lock and Dam. The relatively low standard deviations for the different tests indicate consistency of the samples tested.

# Maximum and residual shear stress criteria

- 65. The following discussion of shear stress criteria is taken from Zeiglar (6) and is followed in this report.
- 66. Designers are commonly interested in the maximum available shear strength. The maximum shear stress points are identified as  $\tau_{\text{max}}$  in Figure 1. The maximum shear stress usually corresponds to the peak of the shear stress versus displacement plot (curve a of Figure 1); however, some confusion may arise where strain-hardening is encountered. When strain-hardening occurs, an initial peak usually occurs at a relatively small displacement, followed by an increase in shear stress to a value greater than the initial peak. When this happens, the first peak is termed the maximum shear stress corresponding to initial failure and the latter is the ultimate shear stress.
- 67. If the residual shear strength is to be determined from the intact specimens, then displacement is continued until the shear stress

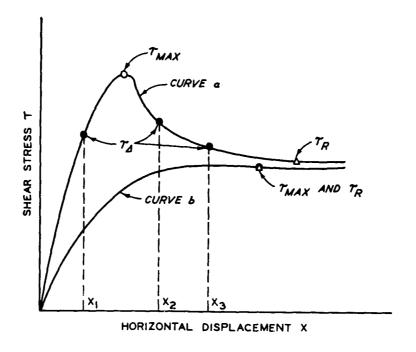


Figure 1. Maximum and residual shear stress, and displacement failure criteria, after Zeigler.

approaches the horizontal asymtotic value of residual shear stress  $\tau_R$  (curve a of Figure 1). When the zone tested exhibits only a residual shear strength, curve b of Figure 1 may be obtained. In such cases, the maximum shear stress attained is the residual shear strength; precut specimens exhibit this type of curve. The shear strength obtained from precut specimens approaches the residual shear strength.

#### Maximum and residual shear strengths

68. Two types of direct shear tests were conducted to determine maximum strength of intact specimens and sliding friction properties of discontinuous specimens. Maximum strength was measured for intact dolomite parallel to and across bedding planes. Sliding friction properties were measured for specimens along precut surfaces, including concrete on rock and rock on rock. The direct shear test results of intact specimens are presented in Plate 22; shear stress values, load-deformation curves, and typical normal versus shear deformation curves are presented. The

direct shear test results from the discontinuous specimens tested as precut specimens are presented in Plates 23 and 24. Maximum and residual strength failure envelopes for the intact and discontinuous specimens are presented in Figure 2.

- 69. Intact specimens containing the two types of bedding surfaces were sheared parallel to bedding. The shear stress values obtained on specimens containing Type A surfaces were extremely high. The shear strength parameters for the Type A surfaces were  $\phi = 81$  deg and c = 198 tsf. The shear strength parameters for the Type B surfaces are lower:  $\phi = 56.2$  deg and c = 45.6 tsf. Specimens with both types of bedding surfaces had good shear breaks. The shear gap between the shear blocks was 1/16 in. The specimens sheared within this gap or within  $\pm 3/16$  in. of the gap.
- 70. Triaxial (TX) tests were performed on the dolomite to compare the angle of internal friction from TX to the relatively high friction angles obtained from the direct shear tests on surface Type A. Values of  $\phi$  = 62 deg and a c = 198 tsf were obtained from the TX test results; see Plate 25. The results from the direct shear tests on the Type B bedding were judged to be appropriate.
- 71. Almost all shear failures of the intact specimens tested parallel to bedding were by breaking through the hard, thin shale features. Only a few asperities on the Type A surfaces sheared at the base. None of the asperities on the Type B bedding surfaces were sheared. As shear deformation occurred dilation began and one-half of the specimen rode up over the other. Attempts were not made to determine residual friction from the intact specimens. Precut rock specimens were used to determine the residual strength values. The sliding friction values for precut dolomite are  $\phi$  = 29.7 deg and c = 0.
- 72. The interlocked bedding plane asperities and the inability to trace continuous bedding plane discontinuities across the site imply that any large-scale failure would involve substantial shearing of intact rock. Therefore, the residual value is not expected to control sliding beneath the lock or dam.

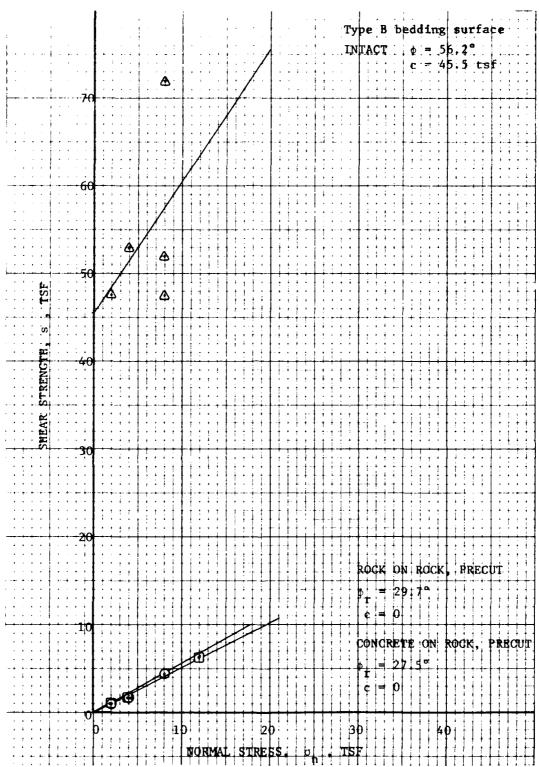


Figure 2. Direct shear test results, maximum and residual shear strength failure envelopes

- 73. After considering (a) the interlocking nature of the bedding surfaces, (b) the intimate and intact shale-dolomite rock fabric, and (c) because previously failed seams or indications of past horizontal movement in the bedrock were not observed, it is thought that peak shearing resistances of the shale features associated with the most nearly planar bedding surfa es (Type B) would control sliding. These peak shear strengths are recommended for computing stability, i.e.,  $\phi$  = 56 deg and c = 45.6 tsf.
- 74. Cross-bed shear tests were conducted (see Plate 26). The test results are widely scattered and no failure envelope was determined. It is suggested that cross-bed shear tests be performed in the future to determine this shear strength value. However, at this time it is considered reasonable to use the intact shear strengths for cross-bed shear strengths. Stagg and Zienkiewicz state that:

"When the directions of loading are such that the potential failure surfaces must cut across the structural features, the shear strength will approach that of the intact rock material."

Structural features, as mentioned in the quote from Stagg and Zienkiewicz, typically include joints, shear zones, and faults. At this site, the ubiquity of tightly interlocked asperities on the bedding planes justifies their inclusion in the class of "structural features" across which shear must occur.

#### Recommended Design Values

75. Design should consider the rock and the bedrock structural characteristics described herein. Guidance is presented in the following tabulation as to proper choice of design parameters:

Rock Property	Dolomite
Effective Unit Weight, 1b/ft3	171.1
Dry Unit Weight, 1b/ft <sup>3</sup>	169.9
Compressive Strength, psi	20,050
Shear Strength	
Intact, Type B bedding	$\phi = 56.2^{\circ}$
	c = 45.6  tsf

Rock Property	Dolomite
Precut, rock on rock	$\phi_{\mathbf{r}} = 29.7^{\mathbf{o}}$
	c = 0
Precut, concrete on rock	$\phi_{\mathbf{r}} = 27.5^{\mathbf{o}}$
	c = 0
Cross bedded	φ = 56.2 <sup>0</sup>
	c = 45.6 tsf
Triaxial Strength	φ = 62 <sup>0</sup>
	c = 198 tsf
Modulus of Elasticity, x 10 <sup>6</sup> psi	7.35
Poisson's Ratio	0.28
Shear Modulus, x 10 <sup>6</sup> psi	2.87

#### Conclusions and Recommendations

- 76. Based upon a visual inspection of the lock and dam, core samples, and laboratory test results, the following conclusions seem warranted:
  - a. The rock masonry in the lock appears sound and has held up well in the severe winter conditions; it should continue to serve its original intended purpose, even though the outside surface is weathered.
  - b. The concrete in the lock and dam is locally cracked and lightly deteriorated. The deterioration is due to cycles of freezing and thawing. Each tainter gate pier has cracks adjacent to the hinge pins that go through the piers. The cause of these cracks is not postulated. The concrete in the dam is structurally sound and should continue to serve its originally intended purpose.
  - The lock and dam is founded on competent bedrock which contains a minimal number of discontinuities. Jointing is minimal. Shale features occur along irregular bedding planes; they are thin and considered as part of the rock fabric, and they should have no effect on sliding stability. No soft or otherwise weak zones were detected in the bedrock.
  - d. It is our opinion that no significant scour has occurred behind the dam. Sounding behind the dam should be made to verify this opinion.
  - e. We suggest that a study be conducted to ascertain if the reinforcing steel in the downstream portion of the tainter gate piers is badly corroded. An area around one of the hinge pins could be excavated for this purpose.

#### REFERENCES

- U. S. Army Engineer District, Chicago, "Periodic Inspection Report No. 1," Cedars Lock and Dam, Lower Fox River, Wisconsin, Feb 1976.
- 2. Letter, NCCED-DC, dated 26 Dec 1979, subject "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures Lower Fox River, Wisconsin, Appleton Locks and Dams;" attached to this letter is NCDED-T (26 Dec 79) 1st Ind, subject as above, and NCCED-DC (26 Dec 79) 2d Ind, subject as above.
- 3. Letter, NCCED-DC, dated 11 Mar 1976, subject "Periodic Inspection and Continuing Evaluation of Completed Civil Works Structures Lower Fox River, Wisconsin, Cedars Lock and Dam;" attached to this letter is NCDED-T (11 Mar 76) 1st Ind, subject as above, DAEN-CWE-B (NCCED-DC, 11 Mar 76) 2d Ind, subject as above, NCDED-T (11 Mar 76) 3d Ind, subject as above, NCCED-DC (11 Mar 76) 4th Ind, subject as above, NCDED-T (11 Mar 76) 5th Ind, subject as above, NCCED-DC (11 Mar 76) 6th Ind, subject as above, NCDED-T (11 Mar 76) 7th Ind, subject as above.
- 4. U. S. Army, Office, Chief of Engineers, "Engineering and Design: Soil Sampling," EM 1110-2-1907, 31 Mar 72, U. S. Government Printing Office, Washington, D. C.
- 5. U. S. Army Engineer Waterways Experiment Station, CE, "Rock Testing Handbook," Test Standards 1980, Vicksburg, Miss., Aug 1980.
- 6. Zeiglar, T. W., "In Situ Tests for the Determination of Rock Mass Shear Strength," TR No. S-72-12, Nov 1972, U. S. Army Engineer Waterways Experiment Station, CE, Vicksburg, Miss.
- 7. Stagg, K. G. and Zienkiewicz, O. C., <u>Rock Mechanics in Engineering Practice</u>, John Wiley and Sons, London, 1968, p 46.

Table 1

Boring, Locations, Elevations, and Starting Date of Boring

Cedars Lock and Dam, Lower Fox River

	Start	Date	2 Aug 1980	Aug 1980	Aug 1980	Aug 1980	Aug 1980	Aug 1980	22 Aug 1980	Aug 1980	Aug 1980	Aug 1980	Aug 1980	Aug 1980	Aug 1980
			2	16	12	∞	13	16	22	19	23	22	22	18	22
El Bottom	of Boring	ft	659.90	679.10	666.10	656.97	664.75	665.35	662.21	682.11	679.71	681.06	697.33	696.30	697.73
El Top	of Rock	ft	09.989	684.20	686.20	683.02	686.60	687.10	683.41	685.46	685.91	686.26	ì	ì	}
El Top	of Boring	ft	704.00	702.80	703.80	706.97	703.80	687.10	683.41	686.91	685.91	686.26	697.33	696.30	697.73
		Location	Backfill, LLW	Backfill, RLW	Spillway Pier 1	Sluiceway Pier 4	Spillway Pier 7	US of Sluiceway Pier 4	DS of Sluiceway Pier 5	DS Sluiceway Apron, Gate 4	DS of Sluiceway Gate 1	DS of Sluiceway Gate 7	Siurceway Pier 4	Left Abutment.	Sluiceway Pier 3
Type	of	Boring	M	<b>4</b> (	9	•	9	9(	90	90	9	•		•	•
	Boring	No.	C WES E1-80	C WES E2-80	C WES D1-80	C WES D2-80	C WES D3-80	C WES D4-80	C WES D5-80	C WES D6-80	C WES D7-80	C WES D8-80	C WES D9-80	C WES D10-80	C WES D11-80

Vertical 4-in. core hole.

Horizontal 4-in. core hole.

Combined drive sample and co

Combined drive sample and core. Combined drive sample and core with piezometer installed.

Landside lock wall. Riverside lock wall.

LLW, RLW, US

Upstream. Downstream.

Table 2
Water Level Readings
C WES D2-80

		Upper Pool	Lower Pool	Top of Hole Elev, ft D2 (706.97)	Reading
Time	Date	el, ft	el, ft	el, ft	ft
3:30	19 Aug	699.52	689.91	690.37	-16.6
9:25	20 Aug	699.52	690.11	690.63	-16.34
3:30	20 Aug	699.52	690.11	690.62	-16.35
3:00	21 Aug	699.42	690.11	690.00	-16.97
5:00	21 Aug	699.42	690.11	690.33	-16.64
8:30	22 Aug	699.32	690.01	690.27	-16.70
5:25	22 Aug	699.32	690.01	690.27	-16.70
8:25	23 Aug	699.52	690.01	690.37	-16.60
3:30	23 Aug	699.52	690.01	690.25	-16.72

Table 3

Soil Samples Received, Cedars Lock and Dam, Lower Fox River

																			Jarse	coarse			lastic, brow	plastic, brown						
Material	Field Nomenclature	Sampler, and $5-1/2-x$ 4-in. Core	Organics, grass and roots	Gravelly clay, reddish brown	Gravelly clay, reddish brown	Clay	Clay	Clay	Clay	Clay w/one piece gravel	Clay	Clay	Clay	Clay, crumbly	Clay, crumbly	Clay, crumbly	Gravelly sand, clay	Gravelly sand, clay		brown, fine to	Coarse sand	Dolomite	Organic matter, clay and silt, plastic, brown	Organic matter, clay and silt,		Clay/silt, brown, soft	Clay, soft, reddish brown	Clay, soft, reddish brown	Clay, soft, reddish brown	The second of th
Sample	Depth, ft		0.0 - 1.05	1.05- 1.15	1.9 - 2.5	2.5 - 3.4	3.4 - 3.5	3.5 - 4.4	4.4 - 4.5	4.5 - 4.6	4.9 - 9.4	6.4 - 6.5	6.5 - 6.6	6.6 - 7.5	7.5 - 8.4	8.4 - 8.5	8.5 -10.4	10.4 -10.5	10.7 -12.4	12.4 -12.5	12.5 -14	15.3 -20.3	0.2 - 2.4	2.4 - 2.5	2.7 - 4.9	4.9 - 5.0	5.0 - 5.8	5.8 - 6.1	6.1 - 7.2	
	Type Sample	Steel Tube, 5-in. Piston	5-in. steel tube	Jar	5-in. steel tube	5-in. steel tube	Jar	5-in. steel tube	Jar	Jar	5-in. steel tube	Jar	Jar	5-in. steel tube	5-in. steel tube	Jar	5-in. steel tube	Jar	5-in. steel tube	Jar	Splitspoon, jar	5-1/2- x 4-in. core	5-in. steel tube	Jar	5-in. steel tube	Jar	5-in. steel tube	Jar	5-in. steel tube	COLUMN TOTAL COLUMN
Sample	No.	5-in.	ΙΑ	18	10				2D				<b>4</b> 4							6B			1				٣			
Drill	Hole No.		C WES E1-80	C WES E1-80	E1-	C WES E1-80	C WES E1-80	C WES E1-80	C WES E1- 0	C WES E1-80	C WES E1-80	WES E1	C WES E1-80	C WES E1-80	C WES E1-80	C WES E1-80	C WES E1-80	C WES E1-80		C WES E1-80	C WES E1-80	C WES E1-80	C WES E2-80	WES	C WES E2-80	C WES E2-80	C WES E2-80	C WES E2-80	C WES E2-80	
	Date		15 Aug 80		15 Aug 80				15 Aug 80				15 Aug 80		15 Aug 80	15 Aug 80				15 Aug 80	15 Aug 80	15 Aug 80	15 Aug 80			15 Aug 80	15 Aug 80	15 Aug 80	15 Aug 80	

(Continued)

Table 3 (Concluded)

	Drill	Sample		Sample	Material
Date	Hole No.	No.	Type Sample	Depth, ft	Field Nomenclature
		5-in.	Steel Tube, 5-in. Piston Sampler, and $5-1/2- \times 4$ -in. Core	Sampler, and	5-1/2- x 4-in. Core
15 Aug 80	C WES E2-80	4	5-in. steel tube	7.6 - 8.5	7.6 - 8.5 Clay, w/dolomite, cobbles, boulders, gravel
Aug		4A	Jar	7.5 - 7.6	Clay, w/dolomite, cobbles, boulders, gravel
15 Aug 80	C WES E2-80	S	Bag - piston sampler		Clay, w/dolomite, cobbles, boulders, gravel
15 Aug 80		9	Bag - piston sampler	11.4 -16.4	Clay (20%) dolomite (80%)
Aug		7	Bag - piston sampler	16.4 -18.7	Clay (20%) dolomite (80%)
15 Aug 80	C WES E2-80		Box, 5-1/2- x 4-in. core 18.7 -23.8	18.7 -23.8	

Table 4 Samples Received at WES, Cedars Lock and Dam, Lower Fox River

						Core
WES Reference	Drill Hole	Date	Box	Depth		Diameter
No.	No.	Received	No.	ft	Pieces	in.
DET-5 DC-1-A	C WES E1-80	15 Aug 80	1 of 6	17.4 + 20.3	(1-5)	7
В			2 of 6	†	(1-6)	
ပ			3 of 6	25.85 + 30.4	(1-5)	
Q			of	30.4 + 34.75	(1-5)	
ធ			5 of 6	34.75 + 39.7	(1-5)	
[II.			oę	39.7 + 44.1	(1-1)	
DET-5 DC-2-A	C WES E2-80		1 of 1	$(18.65 \div 23.8)$	(1-1)	
DET-5 CON-1-A	C WES D1-80		1 of 9	0.0 + 4.3	(1-2)	9
æ			2 of 9	4.3 + 8.45	(1-4)	7
S			3 of 9	8.45 + 12.7	(1-3)	7
Q			6 Jo 5	12.7 + 17.0	(1-3)	7
CON-1						
DC-3-E			of	1	(1-6)	7
DET-5 DC-3-F			of	21.8 + 26.4	(1-6)	7
DC-3-6			7 of 9	<b>†</b>	(1-5)	4
DC-3-H				$30.3 \div 33.9$	(1-4)	4
DC-3-I			6 Jo 6	33.9 → 37.3	(1-5)	7
DET-5 CON-2-A	C WES D2-80		1 of 11	$0.00 \div 4.55$	(1-2)	9
B			2 of 11	<b>†</b>	(1-2)	7
O			3 of 11	<b>†</b>	$\exists$	4
Q			4 of 11	†	(1-2)	7
ഥ			5 of 11	<b>†</b>	$\Box$	4
DET-5 DC-4-F			6 of 11	↑	(1-4)	4
ၒ			7 of 11	$29.20 \div 33.80$	(1-4)	4
н				<b>†</b>	(1-5)	7
I				<b>†</b>	(1-3)	7
J			10 of 11	† 00	(1-2)	4
×			11 of 11	46.50 → 50.00	(1-4)	4

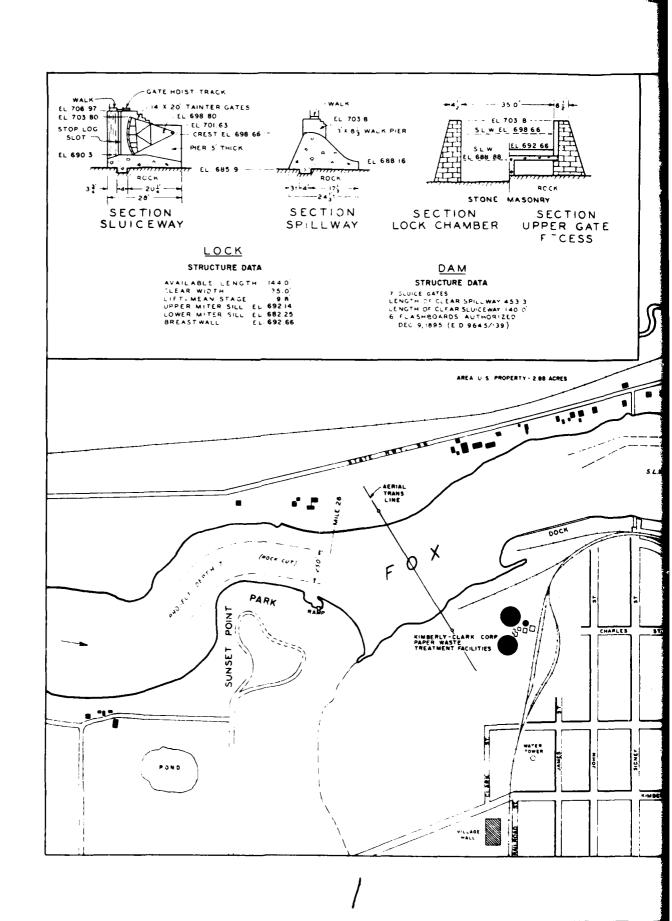
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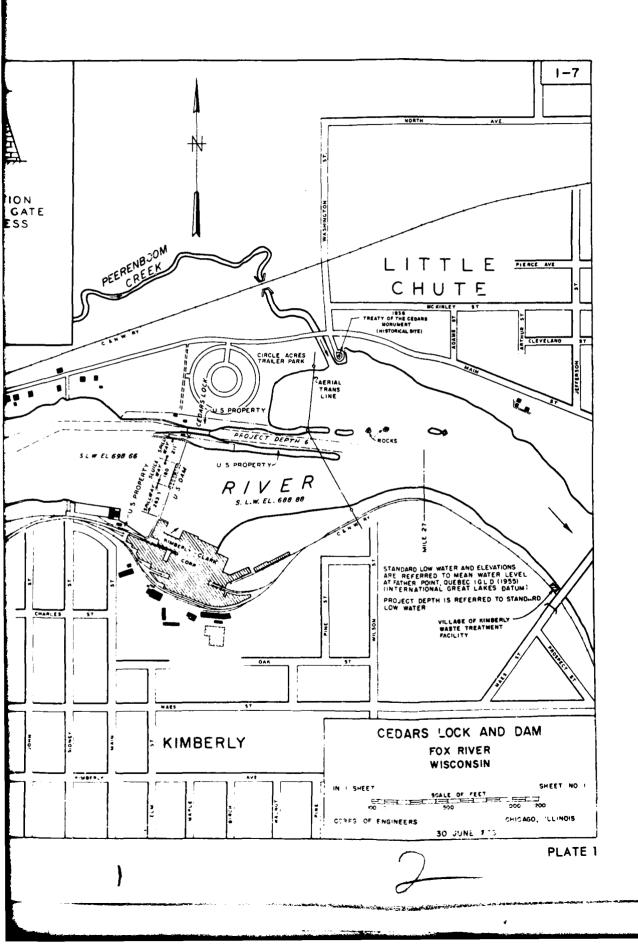
Table 4 (Concluded)

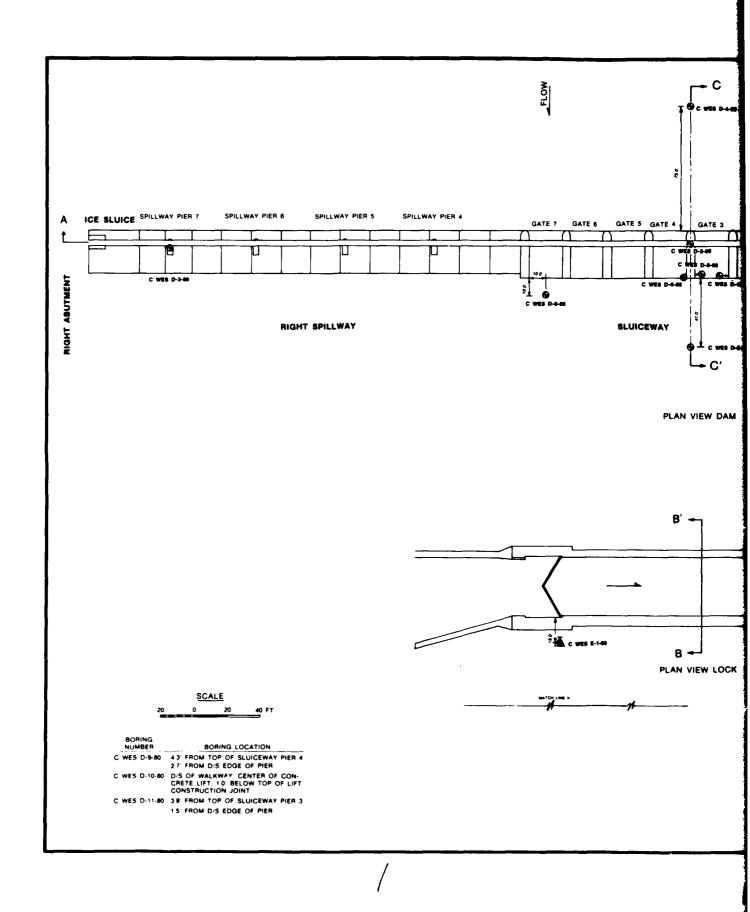
WES Reference	Drill Hole	Date	Вох	Depth		Core
No.	No.	Received	No.	ft	Pieces	in.
DET-5 CON-3-A	C WES D3-80	15 Aug 80	1 of 9	<b>†</b>	(1-2)	6 and 4
В			2 of 9	3.45 + 8.1	(1-3)	7
ນ			of	<b>†</b>	(1-2)	7
Q			6 of 9	$11.2 \rightarrow 15.75$	(1-2)	7
CON-3-						
DC-5-E			of	<b>†</b>	(1-5)	4
DET-5 DC-5-F			6 of 9	<b>†</b>	(1-5)	4
G			of	<b>†</b>	(1-5)	7
Ħ			8 of 9	$29.5 \rightarrow 34.4$	(1-5)	7
I			9 of	34.4 + 38.6	(1-4)	7
DET-5 DC-6-A	C WES D4-80		1 of 5	0.0 → 4.9	(1-7)	7
В			2 of 5	<b>†</b>	(1-5)	7
ပ			3 of 5	<b>†</b>	(1-6)	7
Q			of	13.95  imes 18.2	(1-5)	7
ш			5 of 5	18.2 + ?	(1-2)	7
DET-5 DC-7-A	C WES D5-80		1 of 5	0.0 + 4.40	(1-4)	7
æ			2 of 5	<b>4.40</b> → <b>9.4</b>	(1-5)	4
၁			3 of 5	$9.4 \rightarrow 14.45$	(1-5)	7
Ω				$14.95 \rightarrow 17.95$	(1-5)	7
ы			5 of 5	$17.95 \div 21.2$	(1-2)	7
DET-5 CON-4-A DC-8-A	C WES D6-80		1 of 1	0.0 → 4.85	(1-6)	4
DET-5 DC-9-A	C WES D7-80		1 of 2	$0.0 \rightarrow 3.55$	(1-5)	7
В			2 of 2	3.55 + 6.2	(1-3)	4
DET-5 DC-10-A	C WES D8-80		1 of 1	(0.0 + 4.55)	(1-5)	7
DET-5 CON-5-A	C WES D9-80		1 of 1	$0.0 \rightarrow 2.85$	(1-2)	7
DET-5 CON-6-A	C WES D10-80		1 of 1	$0.0 \rightarrow 2.85$	(1-2)	4
DET-5 CON-7-A	C WES D11-80		1 of 1	$0.0 \rightarrow 2.95$	(1-3)	4

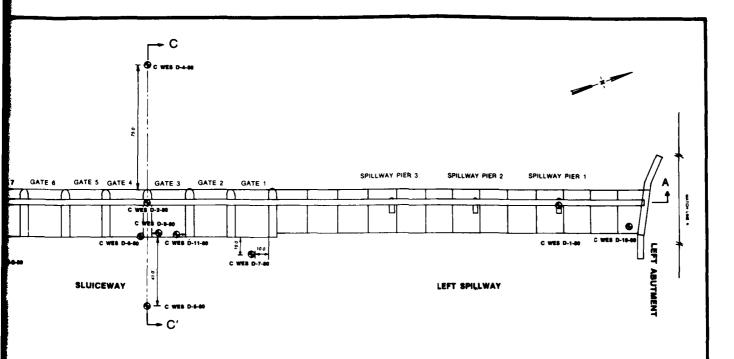
Table 5 Concrete and Rock Core Test Results, Cedars Lock and Dam

			0	Characterization Tests	ion Tests			Engineering Design	esign Tests
		Depth	Effective	Dry	Water	Comp Wave	Comp	Elastic	
Drill	Elev	of Core	Unit Wt	Unit Wt	Content	Velocity	Strength	Modulus	Poisson's
Hole No.	ft	ft	Ym, 1b/ft3	Yd, 1b/ft3	W, pcf	Vp, fps	que psi	$E \times 10^6 \text{ psi}$	Ratio
Concrete									
C WES D2-80	706.5	0.5	153.0	145.9	4.9	16,640	5,920	4.29	0.14
C WES D2-80	696.5	10.5	153.0	145.3	5.3	17,370	8,370	4.65	0.21
C WES D2-80	689.3	17.7	154.2	146.9	5.0	17,705	8,570	5.13	0.26
Avg			153.4	146.0	5.1	17,240	7,620	69.4	0.20
<b>*</b> S			0.7	0.8	0.2	244	1,480	0.42	90.0
Rock									
C WES D1-80	679.2	24.6	171.1	169.7	0.8	19,410	18,780	9.00	0.20
C WES D1-80	6.979	26.9	169.8	168.8	9.0	20,780	20,160	8.00	0.38
C WES D2-80	677.1	29.9	170.4	169.2	0.7	20,150	23,270	6.73	0.32
C WES D2-80	675.8	31.2	171.1	169.6	0.9	20,780	21,840	7.20	0.23
C WES D3-80	683.5	20.3	172.3	170.9	0.8	19,690	19,590	8.17	0.27
C WES D3-80	681.6	22.2	171.7	171.0	0.4	19,410	16,650	5.00	0.27
Avg			171.1	169.9	0.7	20,040	20,050	7.35	0.28
S			6.0	6.0	0.2	989	2,322	1.40	90.0
* Standard deviation	eviation.								

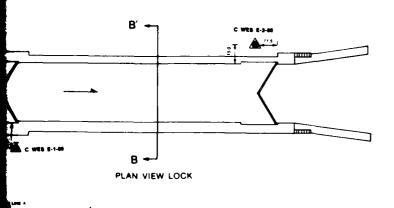








PLAN VIEW DAM



CONDITY VEY
CEDARS LOCK AND DAM
BORING LOCATION PLAN &
GEOLOGIC CROSS SECTIONS

PLATE 2

2

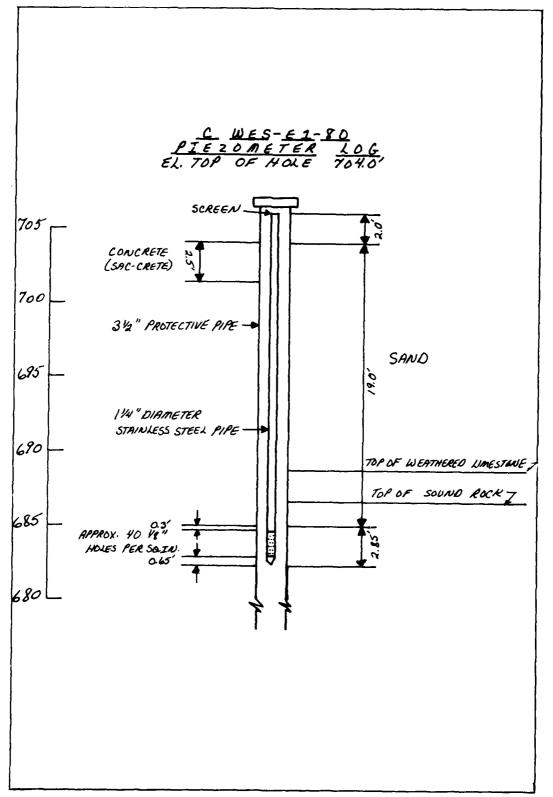
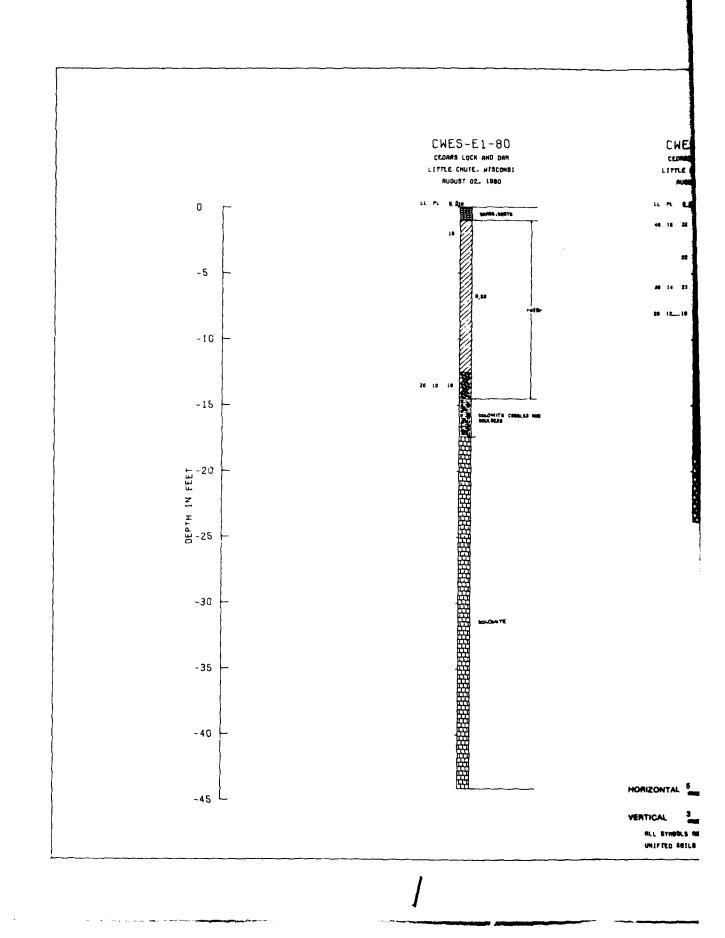
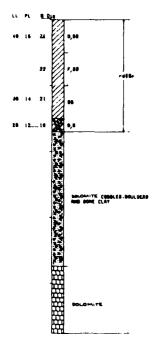
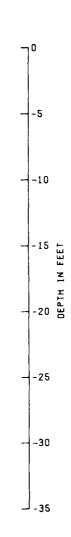


PLATE 3



CWES-E2-80 CEDARS LOCK AND DAM LITTLE CHUTE, HISCONS! AUGUST 16. 1960





SCALES

HORIZONTAL 5 0 5 10 FT

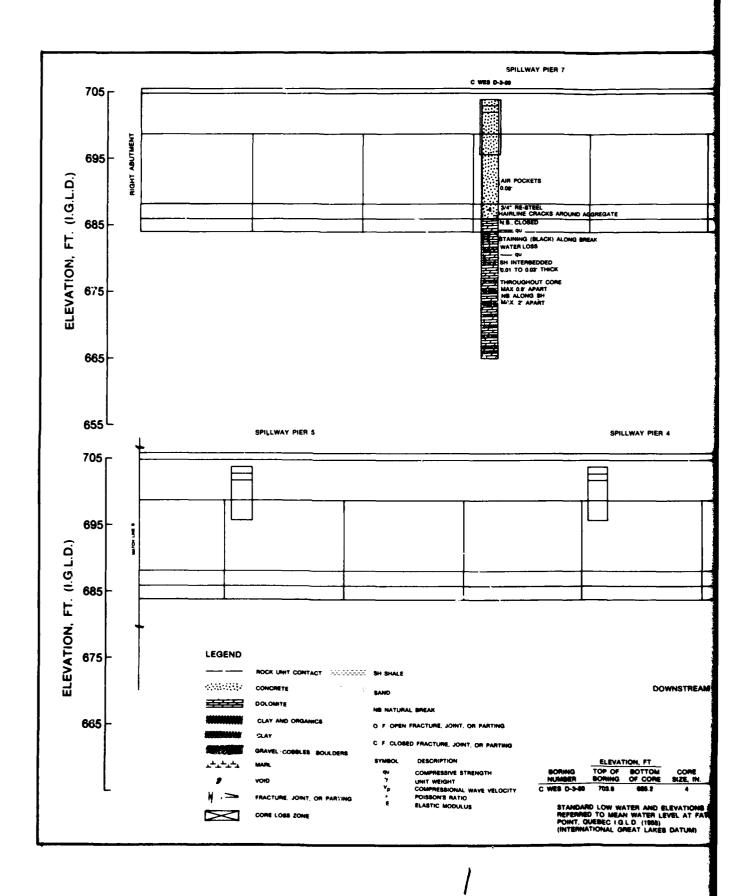
VERTICAL 3 0 3 6 FT

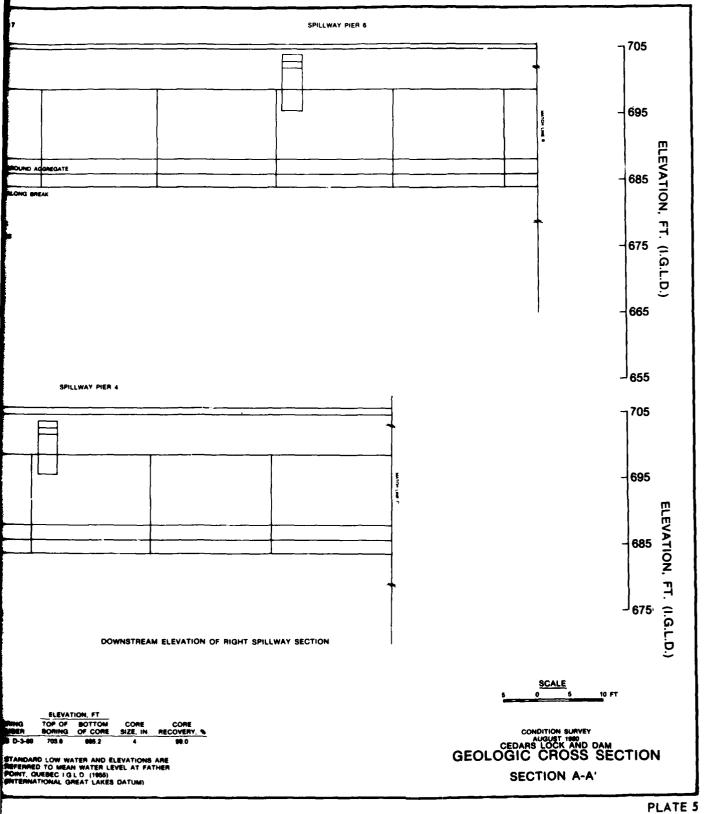
ALL SYMBOLS AND CHARACTERS CONFORM TO THE

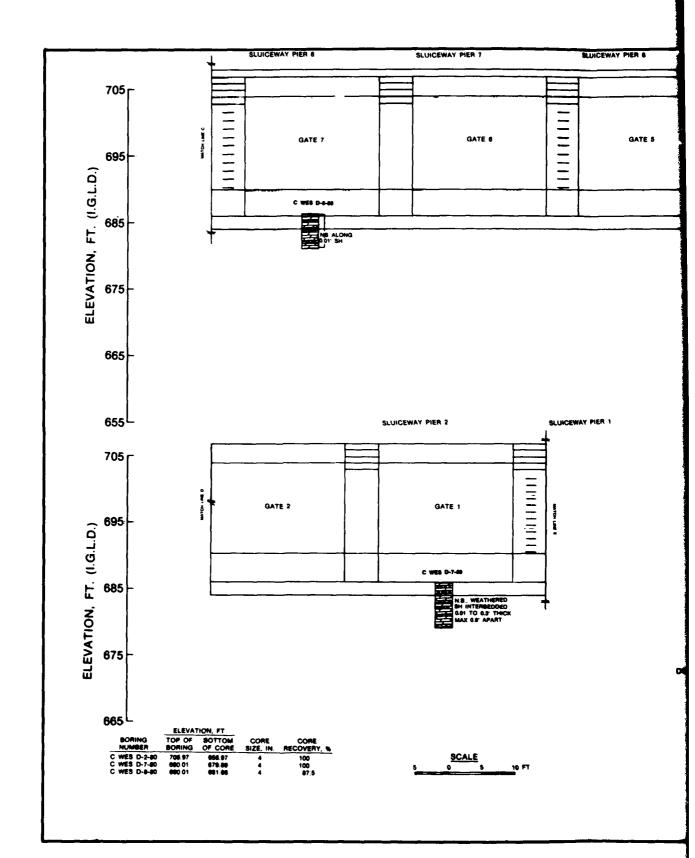
UNIFIED SOILS CLASSIFICATION STOTES

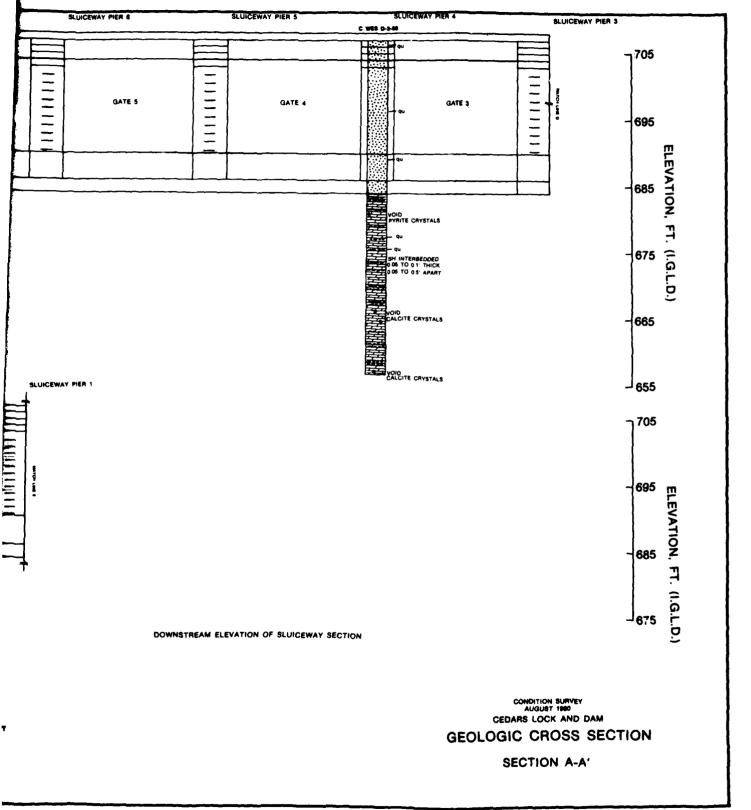
CEDARS LOCK AND DAM

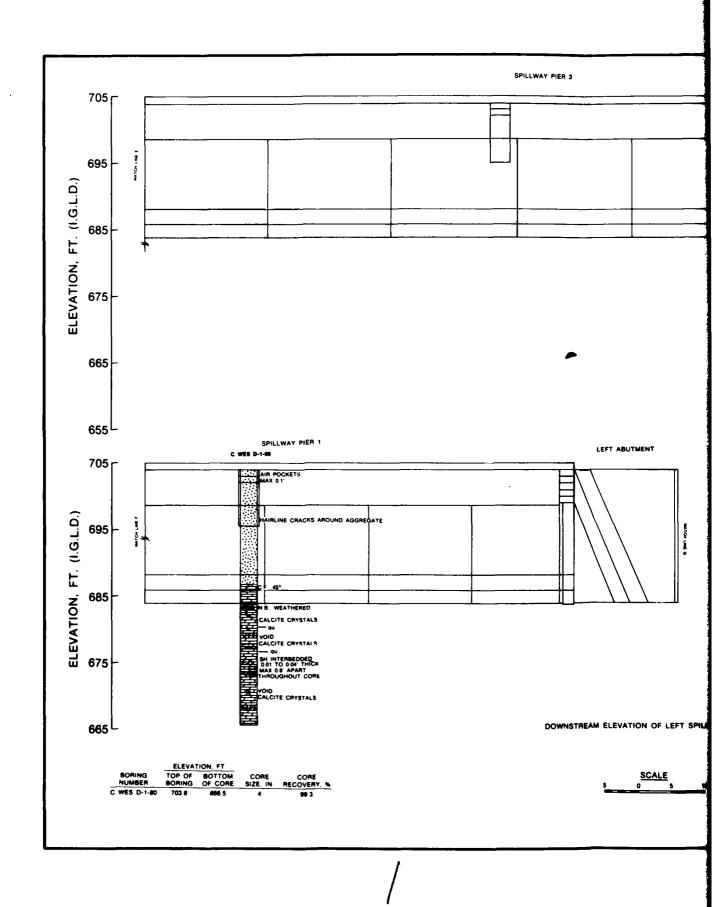
2

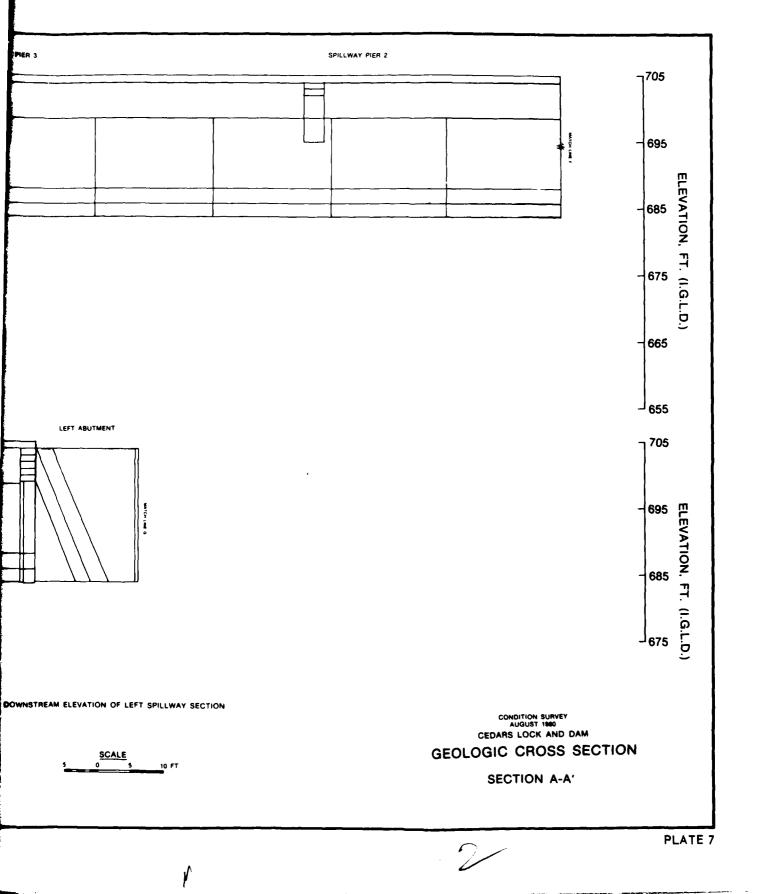












TOS

G95

G95

G95

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GAY AND DRIGANICS

CLAY AND DRIGANICS

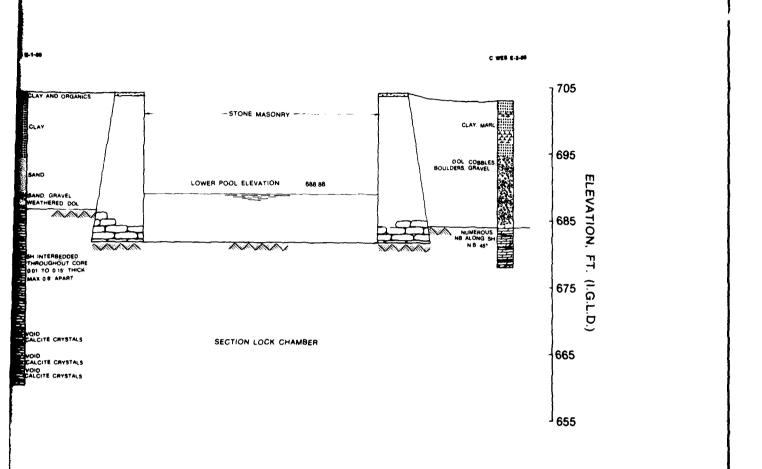
CLAY AND DRIGANICS

SAND



655<sup>L</sup>

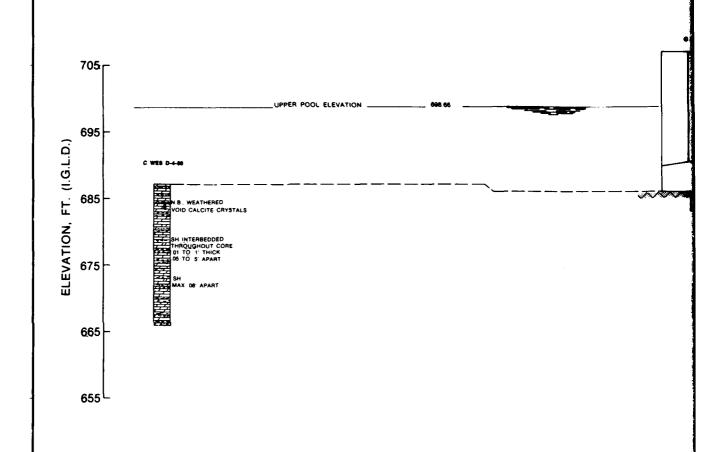
ELEVA		ELEVA	TION, FT		
	BORING	TOP OF	BOTTOM	CORE	CORE
	NUMBER	BORING	OF CORE	SIZE, IN	RECOVERY, %
	WES E-1-80	704 0	659 9	4	100
	WES E-2-80	702 8	679 0	NX	100



CONDITION SURVEY
AUGUST 1960
CEDARS LOCK AND DAM
GEOLOGIC CROSS SECTION
SECTION B-B'

PLATE 8

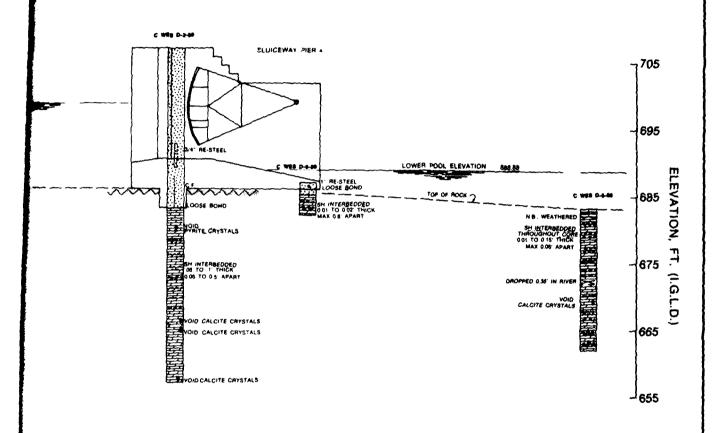
0



SECTION

SCALE 5 0 5 10 FT

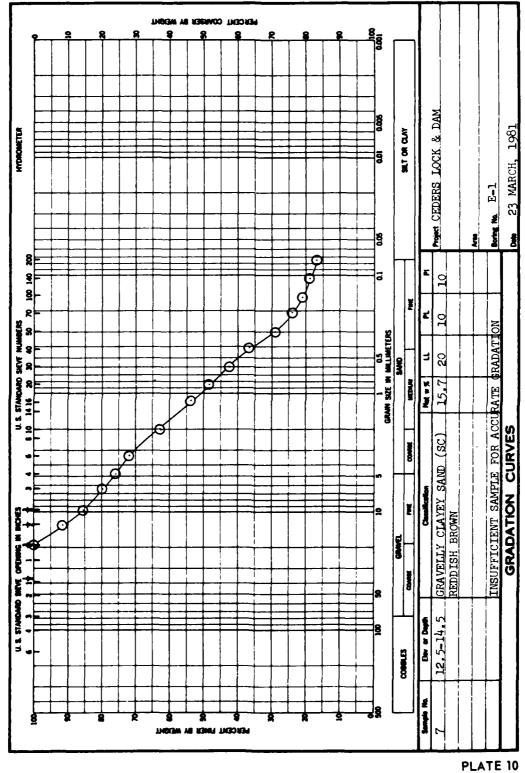
	ELEVATION, FT			
BORING	TOP OF BORING	BOTTOM OF CORE	CORE SIZE, IN.	CORE RECOVERY, %
C WES D-2-80	706 97	656.97	4	100
€ WES D-4-80	667 1	665.9	į.	98
C WES D-5-80	691.41	662.21	4	100
C WES D-6-80	889 91	682 11	4	100



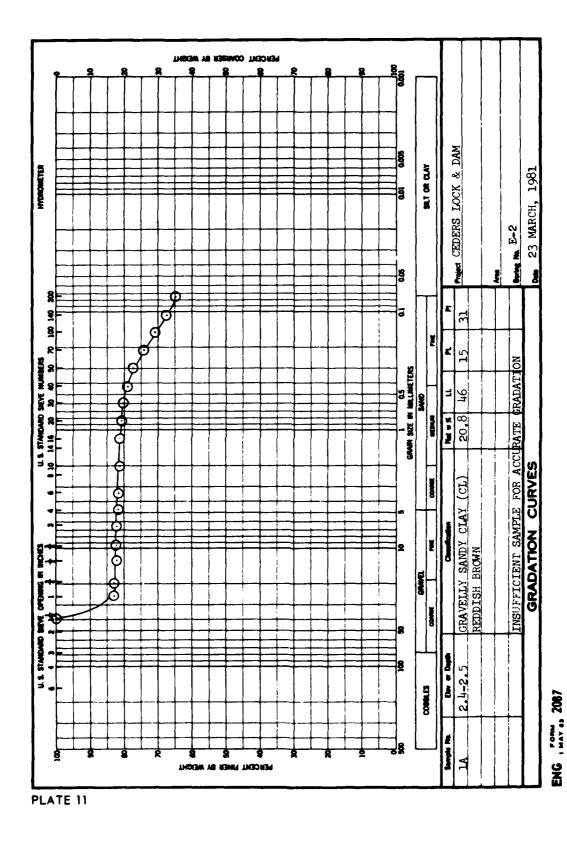
SECTION OF TAINTER GATE PIER
SCALE 1" = 5"

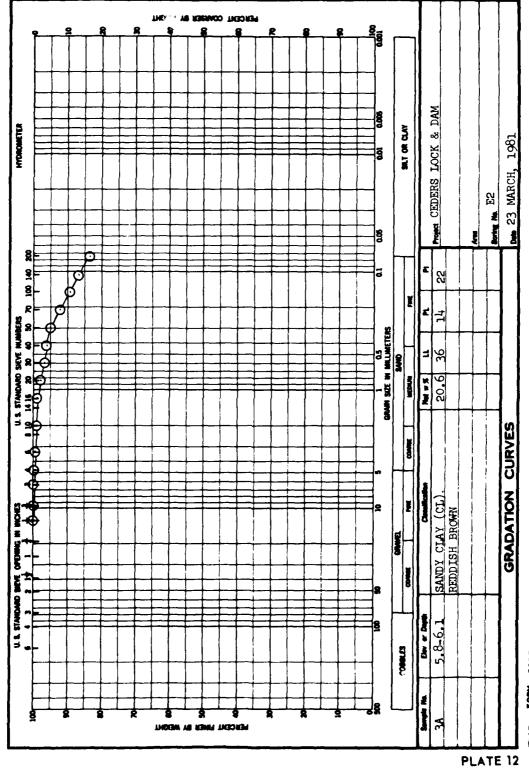
CONDITION SURVEY
AUGUST 1990
CEDARS LOCK AND DAM
GEOLOGIC CROSS SECTION
SECTION C-C'

2



ENG , "AV". 2067





ENG . .... 2087

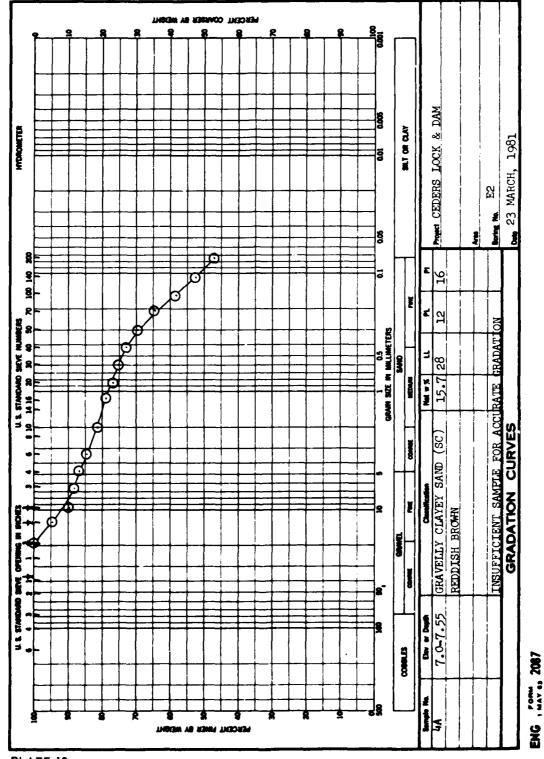
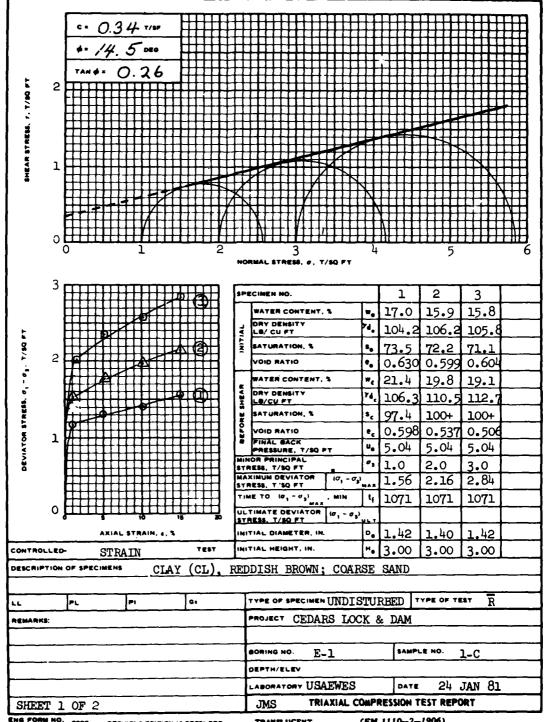


PLATE 13



PREVIOUS EDITION IS OBSOLETE

TRANSLUCENT

(EM 1110-2-1906)

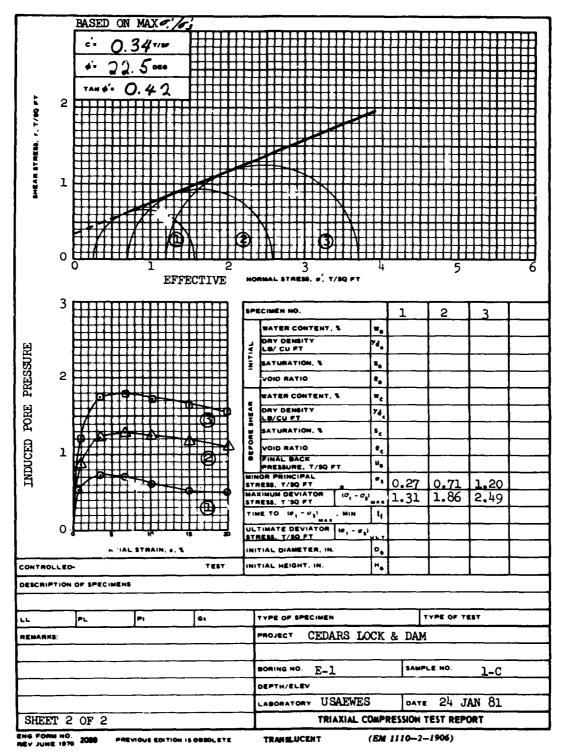


PLATE 15

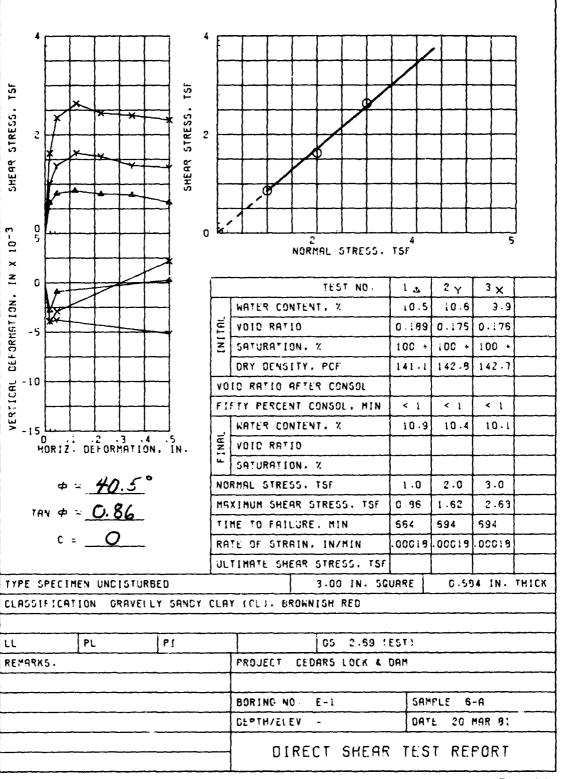


PLATE 16

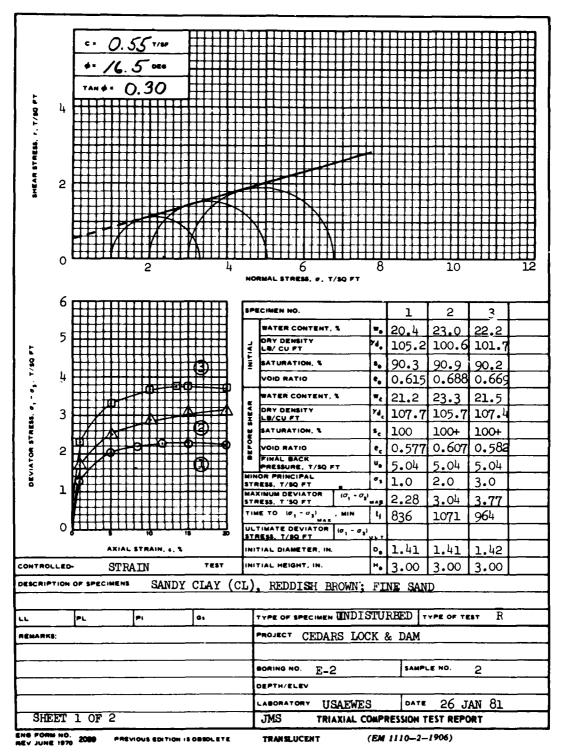
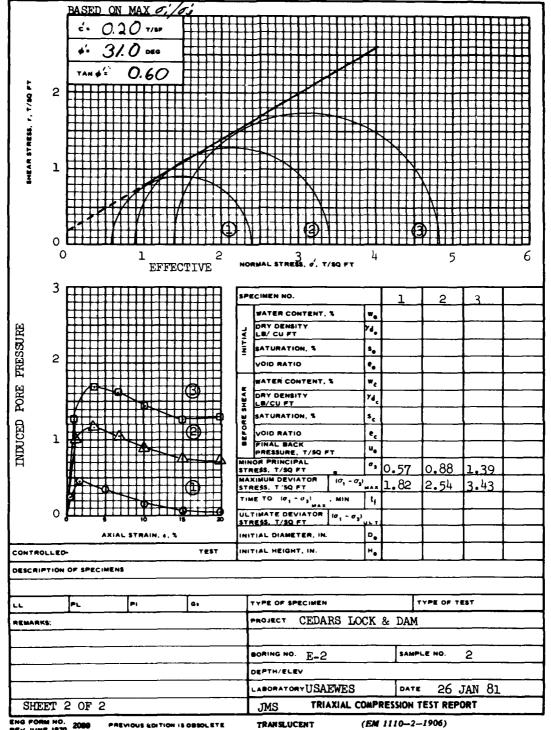
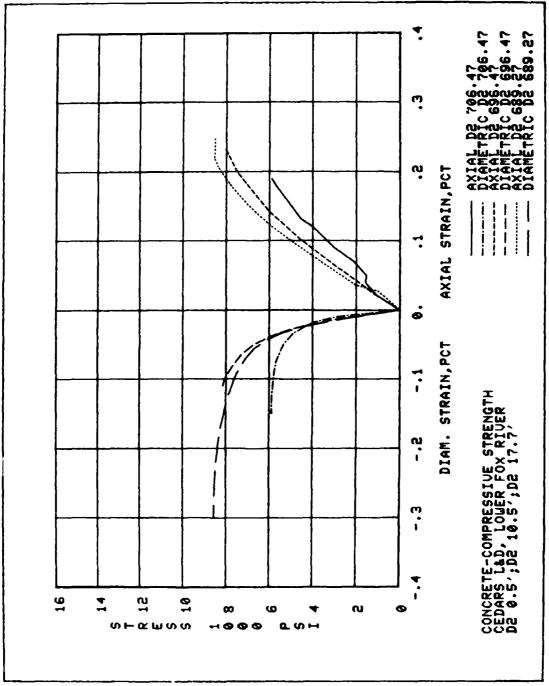


PLATE 17





-

PLATE 19

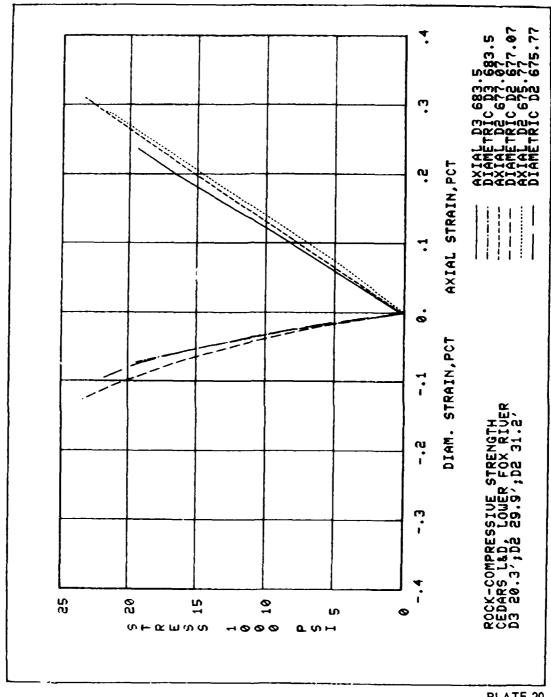


PLATE 20

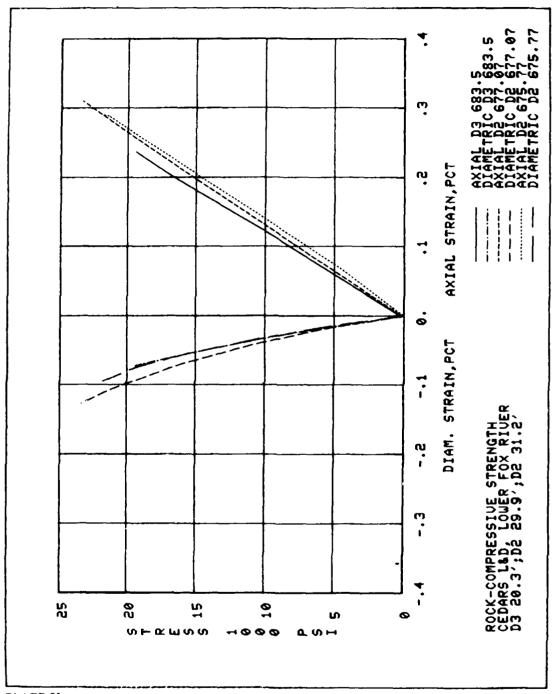
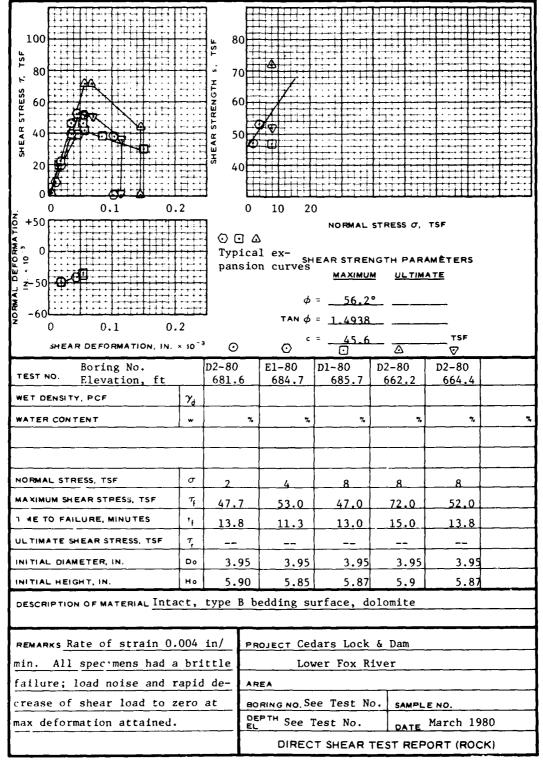


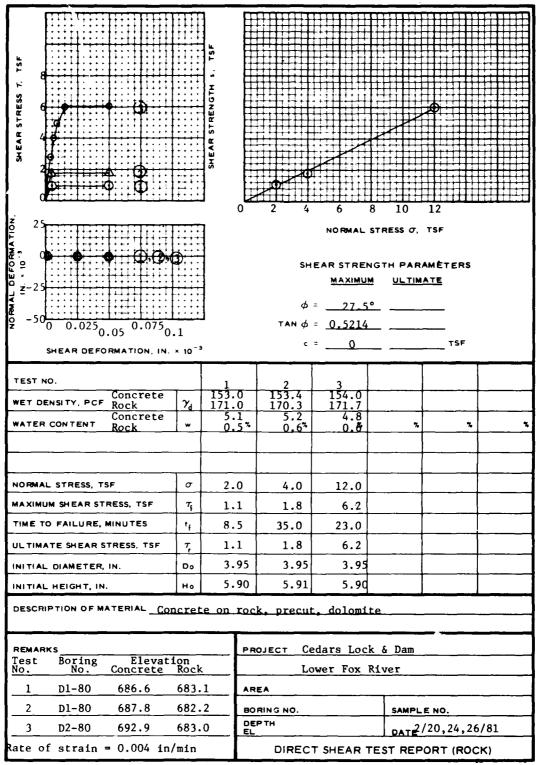
PLATE 21



WES APR 75 1490

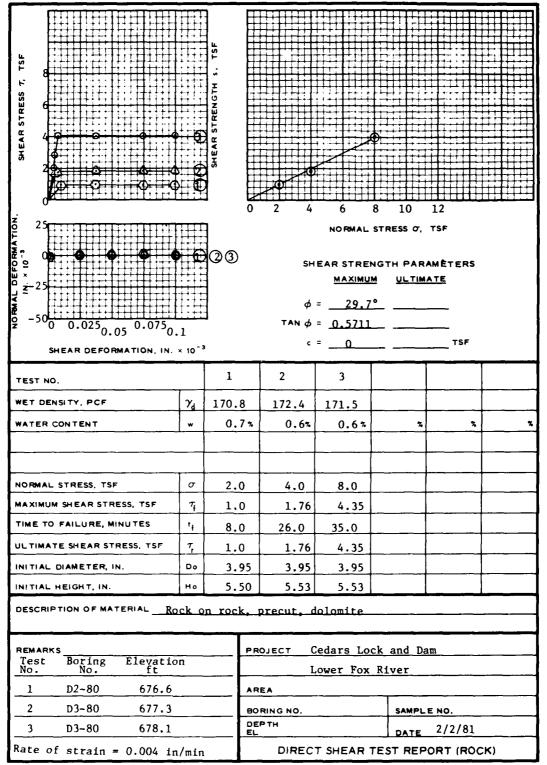
EDITION OF JUN 65 IS OBSOLETE

the second of th



WES APR 75 1490

EDITION OF JUN 65 IS OBSOLETE



WES APR 75 1490

decision in the con-

EDITION OF JUN 65 IS OBSOLETE

The state of the s

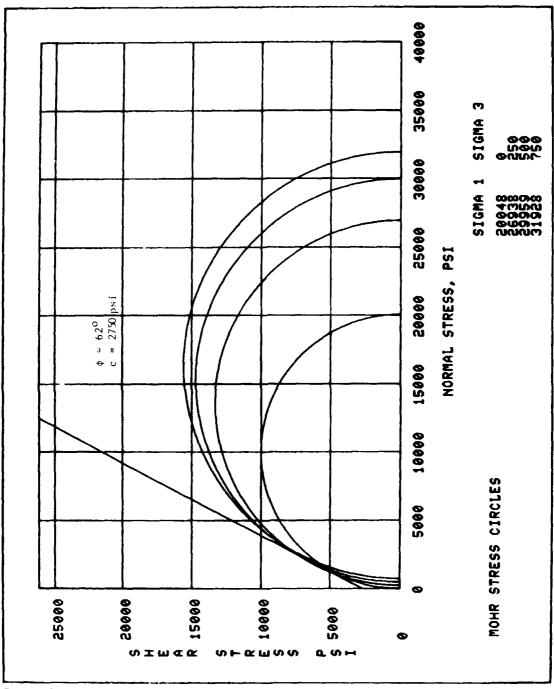


PLATE 25

120 100 100 100 100 100 100 100 100 100	2	SHEA	0	<ul><li>4</li><li>5</li><li>6</li><li>7</li><li>8</li><li>9</li><li>10</li><li>20</li></ul>				
SHEAR DEFORMATION, IN.	10		nsi Æs		EAR STRE	M ULTIM	AMĒTERS	
Boring No. TEST NO. Elevation, ft		D1-80		D2-80 675.8	D1-80 676.0	D3-80 674.8		:
WET DENSITY, PCF	$\gamma_{d}$							
WATER CONTENT	w		%	7.	7,	*	%	3
NORMAL STRESS, TSF	σ	2		4	8	8		
MAXIMUM SHEAR STRESS, TSF	$\tau_{i}$	107		130	88	77		
TIME TO FAILURE, MINUTES	† <sub>f</sub>	18		48	6	6		
ULTIMATE SHEAR STRESS, TSF	$\tau_{r}$	<u> </u>		<b></b>				
INITIAL DIAMETER, IN.	Do			-				
INITIAL HEIGHT, IN.	Ηο							
DESCRIPTION OF MATERIAL		Cross	be	dded. do	lomite			
REMARKS Rate of strain =	0.0	04	PR	OJECT C	edars Loc	k & Dam		
in/min				Le	ower Fox	River		
			AR	EA		<del></del>		
					ee Test N	O. SAMPL	E NO.	
			DE EL	PTH Sec	e Test No	PATE	March	L980
j				DIREC	T SHEAR	EST REP	ORT (ROC	K)

WES APR 75 1490

EDITION OF JUN 65 IS OBSOLETE

PLATE 26

APPENDIX A
PHOTOGRAPHS OF LOCK AND DAM

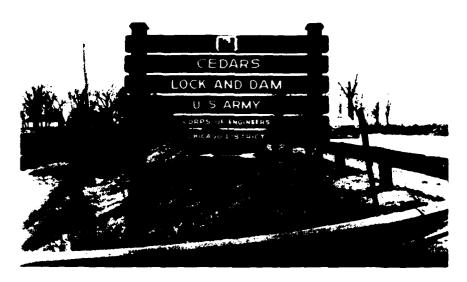


Photo 1. Entrance sign to Cedars Lock and Dam site

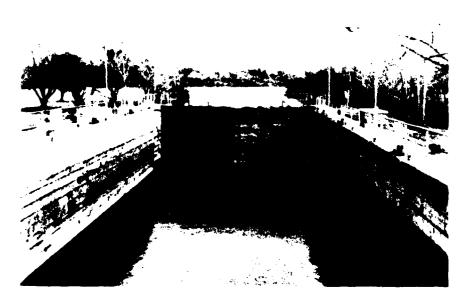


Photo 2. Taken from upstream gate looking downstream. Lock in empty stage

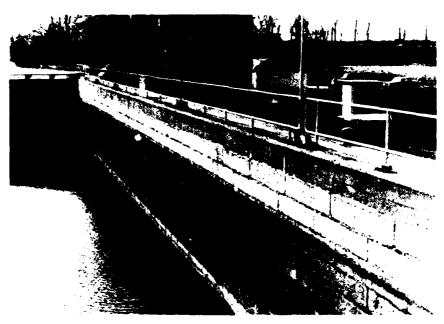


Photo 3. Taken from downstream gate looking upstream at the left lockwall. Close up showing good condition of masonry.

Some joint mortar missing

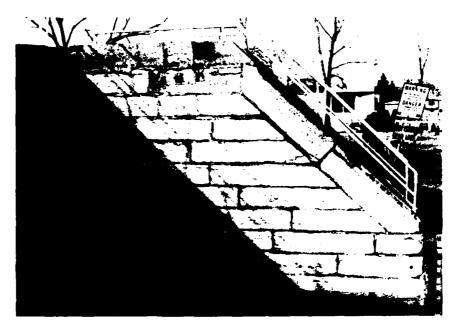


Photo 4. Taken from right downstream bank, showing portion of downstream wooden gate and downstream lockwall. Masonry shown in good condition

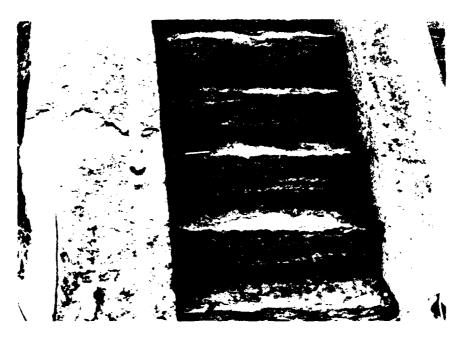


Photo 5. Taken from right downstream bank, showing stairway at end of right lockwall



Photo 6. Taken from right downstream embankment showing portion of stairway and embankment of right lockwall



Photo 7. Taken from upper right side of lock embankment, showing embankment slope and flat between embankment and river



Photo 8. Taken from upper left bank looking downstream, showing right approach wall and upper gate

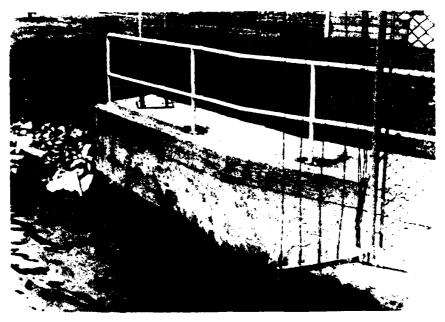


Photo 9. Taken from left spillway, looking at upstream portion of left abutment wall. Resurfaced and original concrete shows evidence of frost damage

Photo 10. Taken from foot bridge atop of left spillway, looking at downstream portion of left abutment wall. Resurfaced and original concrete shows evidence of frost damage

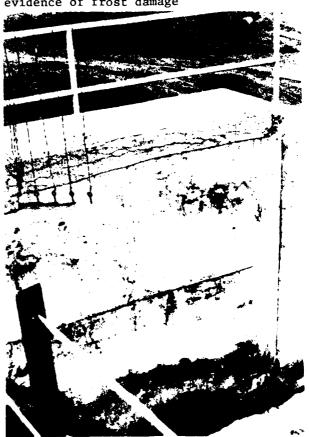




Photo 11. Taken from left spillway foot bridge looking north, pier No. 2, concrete in good condition

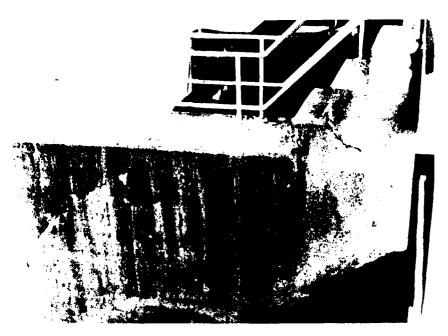


Photo 12. Taken from left spillway foot bridge, looking south, north side of sluiceway pier No. 1

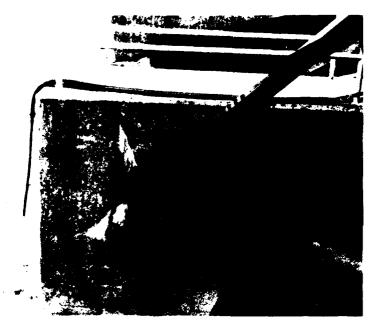


Photo 13. Taken from tainter gate pier No. 1, looking at north side of pier No. 2. Typical cracking through concrete pier at gate hinge pin



Photo 14. Taken from tainter gate pier No. 3, looking at south side of pier No. 2. Crack at gate hinge pin goes through pier



Photo 15. Taken from tainter gate pier No. 8, looking as south side of pier No. 7 showing crack through step of seventh pier



Photo 16. Taken from right spillway, looking at upstream portion of right abutment. Wide diagonal crack in concrete pier. Right dam abutment adjacent to Kimberly Clarke property

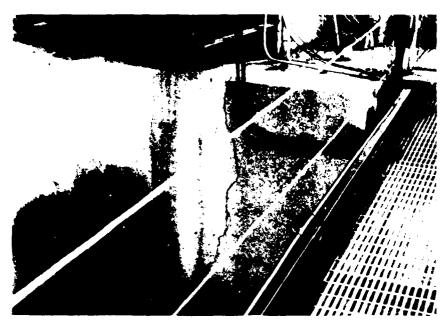


Photo 17. Taken from right spillway, looking at downstream portion of right abutment. Vertical crack to waterline in concrete pier

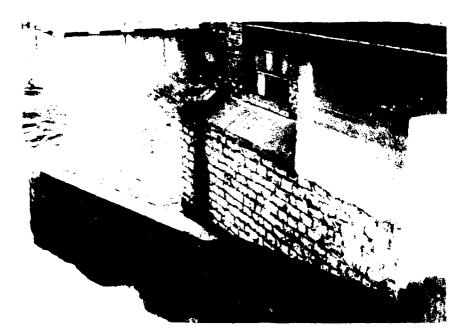


Photo 18. Taken from right spillway, looking at downstream portion of right abutment and masonry foundation wall of Kimberly Clarke plant



Photo 19. View of Murphy Concrete Co. Quarry about 1/4-mile from Kankauna Project Office, left side of Lower Fox River. The rock in the quarry is believed to be the Galena-Platteville dolomite. Horizontal bedding evident



Photo 20. Close-up view of quarry wall

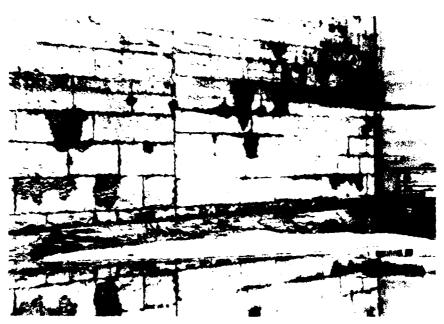


Photo 21. View of dry dock area at the Kankauna Project Office. Downstream of wooden gate showing masonry construction of wall founded on horizontal rock foundation



Photo 22. View just downstream of Photo 21 showing typical bedding structure of founding rock. This rock formation is believed to exist beneath the Cedars Dam

APPENDIX B
DRILLING LOGS

NOTE: All field boring logs identify bedrock as limestone; subsequent petrographic examination shows the bedrock to be dolomite.

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BORING LOG FIELD DATA	Site 200	DENT			SHELBY IUS Z	3	38	\$	35		L'FSWINE		3.4 5. HVENSIOV 1	"	/	7		6"FISHIAM -	5"Hyricaev 6	"	
의 교		Operator C MAKE	SAMPLE	FROM TO	50100	517 50%	52 61						2.5 3.4 6	3.4 3.5	3.5 4.4	4.4 4.5		+	45 4.6 6	19 97	i
		Devent	DRIVE	то	5.0	1.0	51	5.20	5.2		0.0 2.5		3.0	35	4.0	4.5	- 1	4.5	50	155	EDITION OF NOV 1971 MAY BE USED
	* Dav.	Inspector The		TO FROM	0.0 0.0	0.5	1.0	1/5	20		0.0		5.2	50	5.5	4.0		2,5	4.5	5.0	OF NOV 1971
	5 lock	164 Ins	STRATUM	FROM	0.0	0.7															
	C.pm	SKS	DATE		2HUC					_			2 Aug.						1/4		FORM 819
	Project.	Drill Righ	SAMPLE	NUMBER	Z/	10	16		:			`,	124	82	22/	02			SA	38	WES

d			1				<b>201</b> –	BORING LOG FIELD DATA		3		
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Ori:	Drill Rig5// SK	164	Inspecto	100	Duni	0 77	perator	Inspector Joe Dundal Operator La Diake	Su 	rface E	Surface El 204.0 - Boring No Culti-61-60	
SAMPLE		STR/	RATUM	ă	DRIVE	SAM	SAMPLE	TYPE OF				1
NUMBER		FROM	ρ	FROM	Т0	FROM	10	SAMPLER	las.	Pers. Con	CLASSIFICATION AND REMARKS	
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												_
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							ļ	,				Γ
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				0.01 Sib	0.0				300		SOC MANLE WITH JOIN! GAUSE	<u> </u>
				10.0	50/0.2				250		160 W STS + AMROX 10%	
											PUSH: 2.0 (But 0.45" STE 1,4	4
WES IN	FORM 819	EDITIO	N OF NO	/M 1761 V	EDITION OF NOV 1971 MAY BE USED	9					Sheet 2 of 10 Sheets	ets

								10	WEO.M.	His										_
		Surface El 704.0 - Boring No. CIMES-E-1-60	SAGAMED ANA MATERIES DE LA	CLASSIFICATION AND REMARKS	Clenson	•	120 TUBE GRAVELLY SAND - BROWN,	140 JAK Fing to COARSE GRND, MODERNIE	COHESSION, CRAVEL IS FINE TO	SIZE (LUE) STRNTUM CHANGE BESTA	18 6RADUAL - PUSH: 2.0'	Comp. 0.55' SPL 1.30'	(પુરમગળી)		2001		107		_ 1_	CORES GENO JANO (Jun)
	265 60ck	_ Surface E					720 Tub	140 JAK	Soc	45e			 1		390	250	300	525	\ \ \	7
BORING LOG FIELD DATA	Site Led	C. Wake	TYPE OF	SAMPLER	6"Frantain	寸			-)				6"1-sestan		5 //werov 390		<u>,</u>			SMISPOON .
이 교		Doc Unabule Operator	SAMPLE	FROM TO	1		10.7 12.4 5"Hyologov	12425					+		<u>``</u>					,
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	Project Cedals Lor	Drill Rig <i>s/k. Skieley</i> Inspector_	DATE	TAKEN			4DUC							1	11600				1	946
	Project Location	Drill Rig	SAMPLE	NUMBER			64	44							_ *				1	

	18 /oc/( - Do m. Date 2 Aug 1980 Job No. 441 - 57 6-3, 30,6 622 Surface El 704, 4 Boring No. 2465 - E1 - 60	CLASSIFICATION AND REMARKS  CLANGUT - HELE KETT Free LANGUM	Blacked OFF ON LMS Cobbk-	168 16.45 Anklup: 185	(1115-> (See other bys)  (115-> (See other bys)  (115- (a. 0.45- BlockDor)  Sheet 4 of 10 Sheets
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	e Dage #10	STRATUM DRIVE FROM TO FROM TO	125 130	0.0 1465	15.3.76.5 17.9 20.7 EDITION OF NOV 1871 MAY BE USED
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BORING LOG FIELD DATA	1 1 1		TYPE OF	JAMPLEK 11. 01. 01.	E12KKBI -	8"Crisine -	•	WE KUKBT -	K. J. 01	100 h 2						
BOR		Operator C.	SAMPLE	FROM TO	1	8		lo lo		)						۵
	V 004	y Inspector De Quahas	DRIVE	FROM TO	7 206	14,60 1725		202	100	*0.13 44.1						DITION OF NOV 1871 MAY BE USED
	ノスト	<b>ΛΥ</b> ′ Ι	STRATUM	FROM TO											_	ū
	Project (LEDARS	Drill Rig 5#. 56.11		TAKEN				_	-		-				_	FORM 819
	Proje Locat	٥	SAMPLE	NOMBE NOMBE												WES

В6

							Hole Ne	.E-1-190
PRI _L	ING LO	ic T	DETECTI	METALL		100	1 DAY	OF A SHEETS
I. PROJECT					AHD TYP			100/ D PARE 13
CSDA	25 L	<u> </u>	DAY	II. BAT	IN FOR E	CEVATION	н зиови <del>(784 а.</del> н	<b>1</b>
SE E	Goods.	ا <del>لا يم عوام</del> د عرا	quien)	1 14	51			
P DHIFFING	AGENCY	16)	<del></del>	"Z. MAH!	J I-	ZM.2 DES	IGNATION OF DAILL	` 7
CE	wes.			19. TOT	AL NO. OF	OVER-	DISTURBED	UNDISTURBED
4. HOLE NO.	(As show			_ eŭet	DEN SAMP	LES TAK	EN SIX PUSHS	3 GNE
& HAME OF	DRILLER		CWES-E1-86		AL HUMBS			
. (	_, b	PAKE	<u> </u>	IS ELEV	VATION G	ROUND W	ATER	
S. DIRECTION				16. DATE	E HOLE	197	2 Aug do	7 Hours
				17 81 51	ATION TO	08 05 40		7 Hugso
. THICKNES							Y FOR BORING	1047
. DEPTH DR				19. SIGN	ATURE OF	INSPEC	201	<del></del>
S. TOTAL DE	PTH OF	HOLE	44.1	<u>L</u>	4	my	ODehe-	<del></del>
ELEVATION	DFPTH	LEGEND	CLASSIFICATION OF MATERIA (Description)	LIS	REGOV	SAUPLE	(Drilling time, m	ARKS Mor food, depth of L., if significant
•	<u> </u>	150	<u> </u>		Ζ.	L He.	methoring, etc	, il algnillicam)
704.0	0.0-	W.		_			Note: Ro	not done F
1		<b>XXX</b>	CLAY - OPEANIC MATE	<b>*</b> ^	1	1		
7030	10	<del>''''</del>	+		1	1	is Dolon	
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	1	//	,	\		1	1	<b>!</b>
			CLAY (CL)	4		1	1	<b>‡</b>
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	۲	. •	SAND-(SW)	į				E
	ᅼ	v	JANU-(UW)			}	j	E
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	$\Xi$					<u> </u>		. F
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100	_ =	20	WEATHERED LINE		,	l	End /3/	
6880	16-	ارجوا	PURAITICKETY LIKIE	37270	•	1	Time 40m/A	Gaia
j	=	0' 0	, , , , , , , , , , , , , , , , , , , ,	- 1			Hy press	
- 1	7	1. E.	Recovered Alexa	x /0	•	ĺ	Kater pres	• F
1	7	19	OF COAKSE FRAME		NE .	,	RP1 30 - 20	
!	_ 7	17. 1	COBINES	·			Drl Action	Sherife
6870	170-7	C) (	~				Water ret	1/44.4 =
1	🗆	5 a				1	Remarks	/~~ /·
i	7		NO CORE STARTS HERE	_				/ <b>E</b>
ļ	コ	'		- 1		./		on Second
	4		NO - WATHERED -	- 1	511	V		intered Falling
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ì			• •			,	1495)	E
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6850			(15H) eci vi vi vi vi				}	E
			MB		ļ			
684.0	200	-	MP					

	VA				Hole No.	E1-1960
DRILLING LOG	DE trait	CSDA	185	Lock	y Day	OF D SHEETS
CEDAPS /	OCK & DAM	10. SIZE AND	OR EL	OF BIT	SHOWN (TREE of REAL	,
LOCATION (Constitution of	· Station)	¬ M3	7		_	
DRILLING AGENCY	TEN -	- 12. MANUFA		M. 2 DESIG	NATION OF BRILL	
CENES	bowing title	13. TOTAL N	HO. OF	OVER-	Six Pushes	COMMITTURGED
HAME OF DRILLER	CNES- E1-80	14. TOTAL N				: 0110
C. OF AKE		18. ELEVAT	ION GR		TER	
DIRECTION OF HOLE	NED DEG. FROM VEI	IS. DATE HO	DLE			1 AUAKO
THICKNESS OF OVERBUI		17. ELEVAT		P OF HOL	104.0	
DEPTH DRILLED INTO R		19. SIGNATU			FOR BORING /0	07.
TOTAL DEPTH OF HOLE	44.1					
LEVATION DEPTH LEGI	END CLASSIFICATION OF MATE (Description):	RIALS NE	CONE ERY	BOX OR SAMPLE NO.	REMA (Drilling time, was readlering, etc.	RKS or lose, depth of , if eignificant
184.0 700	Run # 1				-	
‡#	2 40	-		Pox		
====	KUN*Z				_	
6830 215	- No core - Rock is	511-	l	11	RUN#2	,
"""一	1			ا ـ	mt	Run 45'
	NS NS		ļ	203	Began 3:51 End 4.1c	Rec 45 Loss -
	SHALEY LIM	STONE		j	TITO 79AM	Gain-
1820 220	1 200		,,	l	171 tame294	CPSI
1 = 1	RED= 88	.9% [/	00/	Box	er press	
1 =	No		´	Dox	El Action	C. Carl
	FINE GRAINED, G	ery indook	لل ج	2	Water ret	1:1
مناجي المربد	- AS Sugary Traines	Foss in	5660	s.	11 16 4.14	<b>^</b>
1810 230	WITH SHALE	COMPER	~ <del>;)</del> ∮	Autes	Regarks /	efi.
=	Bios/Lanina out coers	STRINGER	5-1	hocul	h- Fell-10	<i>!</i> !
]	ALE PANSED	187 K	Den	4 468	<u> </u>	
140 24 =	- 40		-,	ן ייין	Run#3	
86.0 Pre=	-		ĺ		KUN 5	
===	Run 13				FL Began 9.59	Rus 4.2
			- 1		End 10:40	Red 4.2
679.0 250	I,40		ĺ		Time4 mint	Gais —
一门当	~~		J		To biosa	
	<i>'</i>				later press	
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6780260	NR.	İ	}	2515	Mater set	like
	SHA. FV LMS			į	Ti. Iky Allen	7 7
	= NS		-	1	***	
=	NV3 (M)		إرا			
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6770 270	PhD-70	7%	Ì	Box		
	TANK TO	7	- 1	.3	Run# A	
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/a/	1014	1	- 1	ļ	WL -	Rua 495
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674.0 Juc 3-	∟ n <sub>b</sub>				ากหาร <b>ะห์ธ</b>	
			ι	L L		

							Hele No.	CE1-180
0911	ING LOG	DIVISIO	1. 1. 1.	HISTALL	DACS	1	V DAY	SHEET &
1 PROJECT		_	etroit	10. SIZE	AND TYP	C OF BIT	SHOWN (75W & NO.	OF A SHEETS
CEDI	ars Loc	Kd	DAM	11. BAY	JE FOR E	EVATION.	SHOWN (784 & ME	,
Sec	PAGE AGENCY	TEN	<del>-</del>			IN'S DESI	MATION OF BAILL	
DAILLING	VES				+ H		OISTURBED	UNDIETUREED
A HOLE NO.	(As shown on a	coming the	CNES-E1-80	13. TOTA	AL NO. OF	LES TAKE	" SIX PUSHES	one
L HAME OF			CHESTIN		AL NUMBE		OXES SIX	
S. DIRECTION	ORALE			18. ELE	VATION 6			DMPLETED
	CAL DINCLI	440	DES. FROM VERT.	IS. DAT	E HOLE	12	Ava 80	1 Aug 80
			7.41		VATION TO		704.0	
	ILLED INTO R		6.7'		AL CORE !		Y FOR BORING /O	07.
9. TOTAL DE	PTH OF HOLE	- 4	14.1	<u> </u>				
ELEVATION #	0FPTH L <b>EG</b>	.	CLASSIFICATION OF MATERI (Description)	ALS	S CORE RECOV- ERY	BOX OR SAMPLE NO.	REMA (Drilling time, was weathering, etc.	AKS trices, depth of . If significant
674.0	300							E
	<del>                                    </del>	No				30.3		E
	<u> </u>	.						E
673.0	_,, <del>_</del>						Run#5	E
	3/ <b>*</b> = 1	48	Princy las		ļ		EE4	hu 4,6
	∃ ∃		Shary Cons			Box	Boran #2 End /42	Reo 4/6
		,	Suary lm:		1007.	1 1	T AOM	Gain -
	<del>- 1</del>	-;	RUD- 93.5	-//	/00/.	4	Idl time 🗲	Ø5₩  =
620	371-	,	KUV-93.5,	/.		-	Yatenii	5-720
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	│ <del> </del>					[	Drl Activ	Smooth E
	3						Water Fei LrCay/M Remarks	Kle Nil. t E
671.0	330-					1 1	Remarks	`′ ⊨
	<u> </u>	113						F
	] ]							E
	<b>1</b>	4						E
1,00	21/4 7 -		Pun # 5					F
6100	<b>→</b> ,	.] -						E
	_‡-`~	TWO				[ [	•	F
	<b>H</b>	-1	LIMISTONE					E
6670	٠٠ الله	- NA	-			3474	5	E
6612	35 <del>4 -</del> 1 .	1 N3						<b>=</b>
	=	ŀ	_					E
	<del></del>	- 1	SHALE (GETY GET À)					E
1150	E	- 2						F
6680	<b>%</b> ℃		2 SHALL (GREY CREEK)	)				E
	<b></b>		SHALE TOPEPPISH O	PANC	STAIL	S AT		F
	<u>-</u> ]^_^	·rí.	-SHARP CANTACT	(WELL	. DEFI	UEP)	Run#	
100	‡	1	-				411	RIESZ-
667.0	371		DARK GREY IN	s cu	w R		20 17 18 18 18 18 18 18 18 18 18 18 18 18 18	10-0152-
	∄	1	•			Box	248	
			LinicSTONE		1007	יעע ו	-5.4	Jane E
	<b>≒</b> ∵	1	MITTE STUNE		/ /	15	9	16-AC
46.0	211	· ~3	•		,		751	- / F
476.	"飞	-las	RGD: 48	112			1,60	Ymrott E
	<b>4</b>	1 .	1,40 70	''/'			1.2	/ Let =
	<u> </u>	~4					יו פניים יא	′ F
1100	796 J.							E
6450	396-	1 8	N # 6			59 L		F
	====	- 1						<b> </b>
, ,	-;		Linestons					E
644.0	Aco =		K (I IESIVIE)					E
ENC FORM	<u> </u>	14.6			PROJECT	ــــا		HOLE NO.
MAR 71	1836 PRE	110US ED	TIONS ARE OBSOLETE		- HUJECT			

							pa. 1. 44.	C. PHIS
	NG LOG	DIVISION		WHEY A)	LATION	1	Post (	SHEET O
PROJECT				10. 112	DUTS	CCCCY	SHOWN THE - ME	OF O SHEETS
Cedar	5 Loca	er Station	М		OH FOR EL	MOITAVS.	SHOWN TYPE MEE	<del></del>
See P	Anc.	or Station) TEN		\12 MAI		ER'S OESIG	MATION OF DRILL	
DRILLING A	ES.			59	H	AVE-	DETURBED	UNDISTURBED
HOLE NO (	40 000 000 000	desire title	CNES-E1-90	19. 100	AL NO. OF	LESTARE		
NAME OF DE	RILLER		cres er se		AL HUMBE			
. DIRECTION	DRAK.	ك		-+-		I STA	100	OMPLETED
VERTICA			DES. PROM VE	(A T.	E HOLE	12	Hug 80	7 aug 80
THICKNESS	OF OVERBL	ROEN /7.	/		VATION TO		FOR BORING /4	. 7
DEPTH DAIL				19. \$16	MATURE OF	INSPECT	OR	<del></del>
TOTAL DEP					1 CORE	BOL OR	REMA	MK1
ELEVATION	DEPTH	SEND .	LASSIFICATION OF MAT	ERIALS	MECOV.	BO) OR SAMPLE NO.	(Drilling time, 100 meditoring, sic.	ter loss, depth of , if significant
1.640	100	<del>-   -</del>			1	+ - 1	- Eun	7
21014	7 3.	'	Run #7		2.16%	] ]	WL Began ? ??	Run 27
ļ	- ; - ;	, - ns -	<u> </u>		+	<del>                                     </del>	End 120	Reo /۶۶ کرم Lo <b>se</b>
	∄'						Te 45mm	Gain
6630	<b>//山</b> ]:	.					Erl t me√ hpd gleis	
-	+	MB		)		ارا	Mater pres	58 /
	-국.	- 1 · · ·	Shaley Lie	ic sitrals	{	Box	Erd Action	Smill
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Project   Cades   Sect   Dan   Location Sec Observed   Daniel   Site   Cades   Location Sec Observed   Daniel    Site   Cades   Cack   Jem     Site   Cades   Cack   Jem     Site   Cades   Cack   Jem     Site   Cades   Cack   Jem     Site   Cades   Cack   Jem     Site   Cack   Jem     Si								<b>1</b> 01 4	BORING LOG FIELD DATA				
Rig ACKSK Inspector J Qualesk Operator CYMS MRKT  E DATE STRATUM DRIVE SAMPLE TYPE OF SAMPLER  ROKE C.C 1.C 0.O 0.5 0.2 3.4 5'bas Sacisty  16/Le C.C 1.C 0.O 0.5 0.2 3.4 5'bas Sacisty  1.S 2.0  1.S 2.0  1.S 2.0  2.S 2.7 44 5'bas Sacisty  1.S 2.0  2.S 2.7 44 5'bas Sacisty  1.S 2.0  2.S 2.7 44 5'bas Sacisty  2.S 2.7 44 5'bas Sacisty  2.S 2.0  4.S 3.5 4.0  4.S 5.0  4.5 5.0  6. Timina.	RIGHT STRATUM DRIVE SAMPLE TYPE OF SAMPLER PROM TO FROM TO FROM TO FROM TO FROM TO SAMPLER SAMPLER PROM TO FROM TO FROM TO SAMPLER SAM	Project	Cade	Slack	1	2				Site 4	Aderis .	Jak.	Livies Chure, WE Date 16 Aubust 8
STRATUM   DRIVE   SAMPLE   TYPE OF SAMPLER   SAMPLER	DRIVE STRATUM DRIVE SAMPLE TYPE OF SAMPLER AND FROM TO FROM TO FROM TO FROM TO FROM TO FROM TO SAMPLER	Location Drill R	ig ACK		Inspecto	1 J B	Jogui	0	perator	CLYNE DEAKT		rface E	
PROM TO FROM TO SAMPLER   10   10   10   10   10   10   10   1	## JAKEN FROM TO FROM TO FROM TO SAMPLER  ### 6.0   0.0   0.5   0.2   3.4   5'DUMSSUELBY  ### 1.0   0.5   1.0   3.4   3.5   7''066  ### 2.0   2.5   2.0    ### 2.0   2.5   2.0    ### 2.0   2.5   2.0    ### 2.0   2.5   2.0    ### 2.0   2.5   2.0    ### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    #### 2.0   2.5   2.0    ##### 2.0   2.5   2.0    ##### 2.0   2.5   2.0    ##### 2.0   2.5   2.0    ##### 2.0   2.0   2.5    ##### 2.0   2.0   2.5    ##### 2.0   2.0   2.0    ##### 2.0   2.0   2.0    ##### 2.0   2.0   2.0    ##### 2.0   2.0   2.0    ###################################	SAMPLE		STR	4 TUM	DRI	VE	SAM	PLE	TYPE OF			
While 6.6   10 00 0.5 0.2 2.4 5" Dum Surers by 10 0.5   10 0.4 4 35 7" 65	7. 16th 6.0 10 0.2 0.2 0.4 5'00mSusing 10 0.5 10 0.2 0.4 5'00mSusing 10 0.5 10 0.4 0.5 7'16s  1.0 1.5 2.0  2.0 2.5  2.0 2.5  2.0 2.5  2.0 2.5  4.0 2.5 49 50  4.0 4.5 5.0  4.0 4.5 5.0  4.1 5.0 6" Fixtfair	NUMBER		FROM		FROM	10	FROM		SAMPLER	PATIS	Gar	- ! !
1.0 0.4 25 Tibs   1.0 0.4 25 Tibs   1.5 2.0   1.5 2.0   1.5 2.0   1.5	7. 1.0 3.4 3.5 77.65 1.0 1.5 2.0 1.5 2.0 2.0 2.5 2.0 2.5 2.0 2.5 3.0 3.5 4.9 3.5 4.9 4.5 5.0 4.5 5.0 6.75479.1 6.75479.1	17#	16Ac	0.0	10	00	0.5	0.2	2.4	5'Dum Sucies	1235	11.45	CRING MATTEL - CLAY SIT, LON
1.5 2.0 1.5 2.0 2.0 2.5 2.0 2.5 2.0 2.7 49 5 Haceur 3.0 3.5 4.9 5.0 4.5 5.0 4.5 5.0 6.75461.	7.5 2.0 7.5 2.0 7.5 2.0 7.0 2.5 7.0 2.7 44 5 412640V 3.5 3.0 2.7 44 5 412640V 3.5 3.0 3.5 4.0 4.0 4.5 4.5 5.0 — 6"Fishing	£ 22.		0/		0.5	01	2.4	25	7786	400	K	Austrein, Blown, DAY, Little Co.
1.5 2.0   750   750   700	1.5 2.0   700   1.5 2.0   700   100   1.5 2.0   700   100   1.5 2.0   700   100   1.5 2.0   700   100   1.5 2.0					1.0	1.5				450		PUSA 2.5' COMP 0.8' SPL 1.
8/0 2.5   700   150	20 2.5 700 (15aun)					/.5	2.0				550		
18/14	2 18/10 2.0 2.7 44 5- Hizera 4cc Lage (191/51) Beaul, 3 5 3.5 4.9 5.0 100 100 plethily, and soft, 40 4.5 5.0 100 100 100 100 100 100 100 100 100 1					2.0	3.5				200		
18/14   2.0 2.7 44 5 Hireau   (15anout   18/14	2 18/w												
18/16 30 2.7 44 5-Arxesov dec Tune (244/Sirī-Tm1/cl) Beanu, 30 3.5 4.9 50 45c 50 pletheity, and soft, 40 4.5 5.0 6 6"Tisuran - Clinnout	2 18/14					6.0	2,5			6 FISHTAIL	Ţ		LESANOUT
18/14	2 1844	\											
5 4.0 6 4.5 6 5.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7.0 7	35 4.0 45 60 450 All polarity and soft, low 1.5° Comp. C. 45 50 60 600 600 600 600 600 600 600 600	#2	18AVK			2.5	30	2.7	49	5. Arzesov	400	line	
5 4.0 6 4.5 6 5.0 7 6.0 7 6.0 7 8.0	40 45 50 650 601 12 12 12 12 12 12 12 12 12 12 12 12 12	#24				.30	3.5	44	50		45c	LAK	proderate colusion, with Lew!
5 5.0   6"TIMA"   CLEANOUT	40 4.5 5.0 [USH: 2.5 COMP. C. 45 SPL 1.2 COMP.					35	4.0						plackith, And Soft,
5 5.0 - 6" FISHTAN - LLIANOUT	4,5 5.0 - 6"TSWA" - (LIANOUT					40	4.5						
5.0 - 6"TIMTAIL -	7.5 5.0 — 6"TSWIAN — (21.4NOUT)					4.5	5.0				980		7
2.C	10 A 10 C C 154/A 11 C 124/A 11 C					1,5	Š			1.47			
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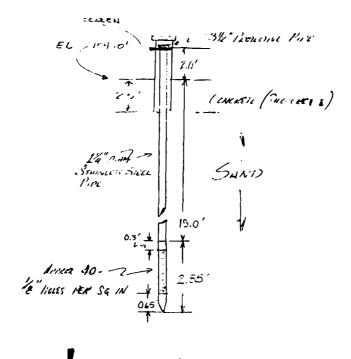
ARMY ENGINEER WATERWAYS EXPERIMENT STATION VICKSBURG--ETC F/G 13/2 CONDITION SURVEY OF CEDARS LOCK AND DAM, LOWER FOX RIVER, WISCO--ETC(U) JUN 82 R L STOWE, J C AHLVIN WES/MP/SL-82-4 CTIAC-52 NL AD-A119 696 UNCLASSIFIED 2 n**€ 2** Δ0 Δ19496 END 11.82 DTIC

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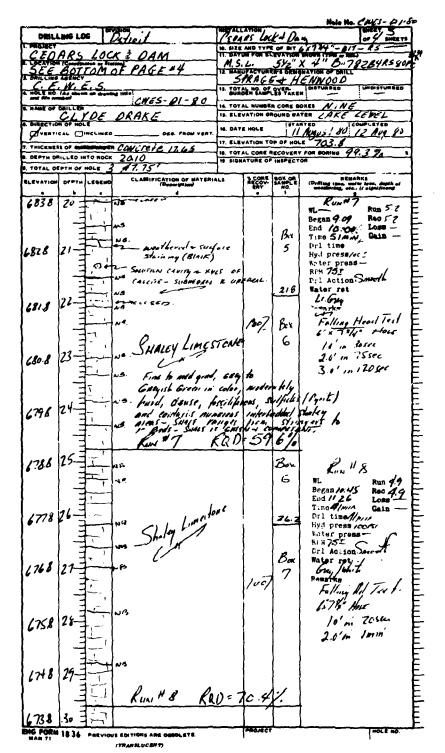
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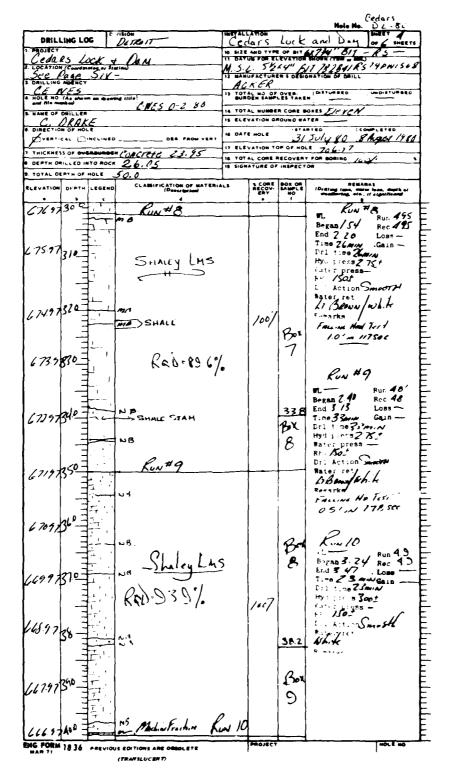


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TOTAL DE	PTH OF	HOLE	50.c	Clay	1	5 B	unhan	
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				Hole No.	CEDANS D-7-FO
DRILLING LOG	DETROIT	CLEARS A	at 3	Don	OF & BHEETS
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LOCATION (Countings)	or Station)	MS.C. 5/2K	4811	PS 284/ES	79PN 156 8
SEE PAG	5/1/-	ACK ER	ER'S DESIG	HATION OF BRILL	
CE WES HOLE NO. (As shown a and file number)	drawing title	19. TOTAL NO. O	OVER-	DISTURBED	UNDISTURBED
HAME OF DRILLER	L 1100 2 2 0 -	14. TOTAL NUMB			5N
DIRECTION OF HOLE	<i>[</i>	IS ELEVATION C		6780 1c	OMPLETED
VERTICAL DING		16. DATE HOLE	130	July 80 8	August 80
	Concrete 23.95	17. ELEVATION T		FOR BORING 10.	
TOTAL DEPTH OF HO		19. SIGNATURE O	FINSPECT	OR	• //
LEVATION DEPTH LE		IALS S.CORE	BOX OR	REMA	nks .
	C (Description)	IALS S CORE	BOX OR SAMPLE NO	(Drilling time, was	er loss, depth of if significant
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							Holo No. 02:-80
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1. PROJECT	,			10. SIZE	AND TYPE	OF BIT	SHOWN TWA WALL
Z. LOCATION	Courte	toe or Sta	<u>Dum</u>	1.5.2	5 5/2	A4 BI	T 74 28 4/ R5 19PWISCE
SEE	PAGENCY	<u> </u>	<u> </u>	TE MANL	PACTURE	M. S DESIG	HATION OF BAILL
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S. HAME OF C		-		IL ELEV	ATION GR	R CORE B	TER
6. STRECTION				16. DATE		1874	TTEO COMPLETED
VERTIC	AL	ICLINED	DES. FROM VERY.		ATION TO		54/4 80 8 August 80
			CONCrete 23.15				FOR BORING 108/. 1
B. DEPTH OR			26.05 50.0		ATURE OF		
ELEVATION .		$\overline{}$	CLASSIFICATION OF MATERIA	11.5	3 CORE	BOX OR	REMARKS
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676 97	<u> 30 c -</u>		dense		PROJECT	<u>,                                    </u>	HOLE NO.

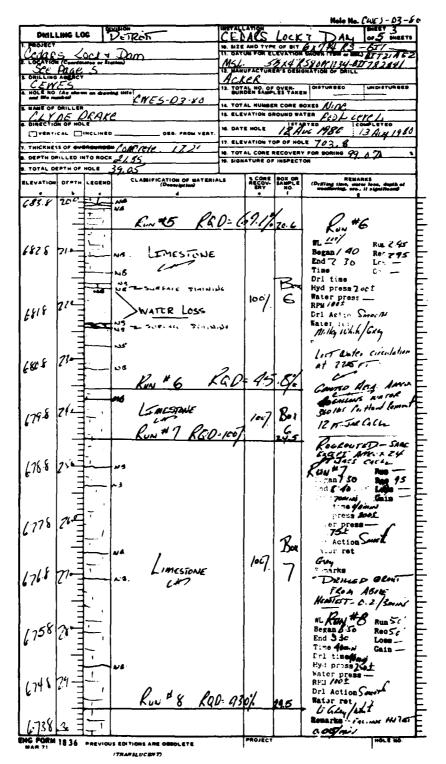


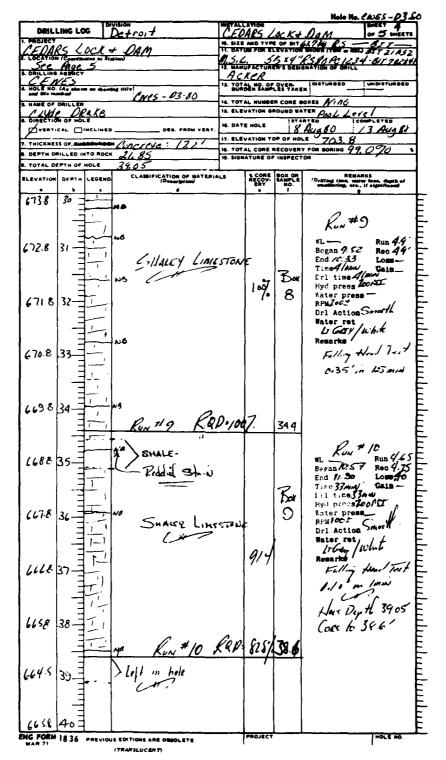
				Hele No.	DZ-1980
DRILLING LOG STUBION	2	FOARS LO	cka		OF & SHEETS
1. PROJECT	10. 1	HZE AND TYPE	OF BIT	1114 BIT	-15-
2. LOCATION (Constitution or Station)	1	5.6.5/27	4'817	18284 RS	74PW1568
SEE PAGE SIX-		CKER			1
4. HOLE HO (As also we as drawing tists	19. }	TOTAL NO. OF	OVER-		UNDISTURBED
and Mo Make of DailLes	1.0	TOTAL NUMBER			N
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DERTICAL DINCLINED DES. PROM	VEA7.	DATE HOLE	131	July Ro 8	AUG RO
7. THICKNESS OF OVERDURSEN CONCLETE 23.	— ا	TOTAL COME O		FOR BORING /C	<del></del>
e. DEPTH DRILLED INTO ROCK 76.05		IGNATURE OF			*
9. TOTAL DEPTH OF HOLE SU, C  ELEVATION DESTH LEGEND CLASSIFICATION OF MI (Peoprinties)	TERIALS	3 CORE	BOX OR	REMAI	RKS
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ENG FORM 18 36 PREVIOUS EDITIONS ARE OBSOLETE.		PROJECT			HOLE NO.

							Hole No.	CEDMES C-DZ=*A
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DRILL	ING LO		DETROIT	Can	MPS 1	Low	3 MAY	OF 6 SHEETS
Ceda	04 1	MK	Dan	11. BATU	AND TYPE	TOP BITE	SHOWN (TOWN OF BELL	- R.5
LOCATION	(Coording	100 or 11m	ion)	11.5.	L. 512			574PNISU8
DRILLING	AGENCY	2/1	<del></del>	12 BANG	K ER	A-S DESIG	MATION OF BAILL	7
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and His ma	~~		C-N-5-0-2-80					<del>!</del>
HAME OF	DRILLER					R CORE B		<u> </u>
DIRECTIO	AKE			IS. DATE		TOTA		99° LETED
VERTIC	AL []"	4CLINES	DES. PROM VERT.			ئىل.	July 10	Aug Ro
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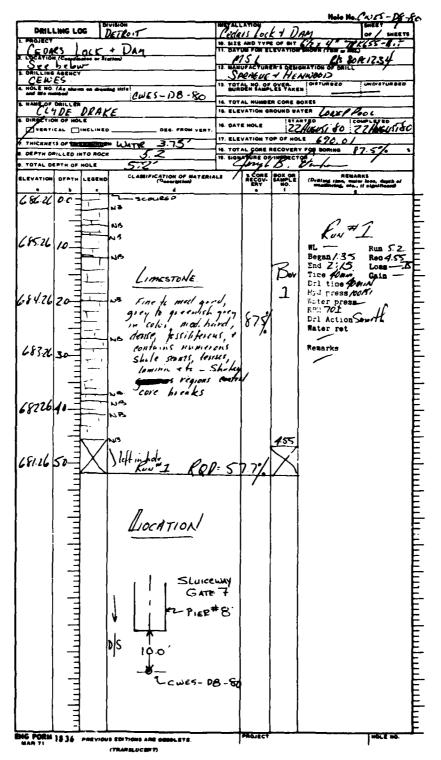
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				THISTALLATION		Hole No. (1055-175-5
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In accordance with letter from DAEN-RDC, DAEN-ASI dated 22 July 1977, Subject: Facsimile Catalog Cards for Laboratory Technical Publications, a facsimile catalog card in Library of Congress MARC format is reproduced below.

Stowe, Richard L.

Condition survey of Cedars Lock and Dam Lower Fox River, Wisconsin / by Richard L. Stowe, Joyce C. Ahlvin (Structures Laboratory, U.S. Army Engineer Waterways Experiment Station). -- Vicksburg, Miss.: The Station; Springfield, Va.: available from NTIS, 1982.

89 p. in various pagings, 26 p. of plates; ill.; 27 cm. -- (Miscellaneous paper; SL-82-4)

Cover title. "June 1982."

Final report.

"Prepared for U.S. Army Engineer District, Chicago." Bibliography: p. 27.

1. Cedars Lock and Dam (Wis.) 2. Concrete dams.
3. Dams--Inspection. 4. Locks (Hydraulic engineering).
5. Lower Fox River (Wis.) I. Ahlvin, Joyce C.
II. United States. Army. Corps of Engineers. Chicago
District. II. U.S. Army Engineer Waterways Experiment

Stowe, Richard L.
Condition survey of Cedars Lock and Dam : ... 1982.
(Card 2)

Station. Structures Laboratory. III. Title IV. Series: Miscellaneous paper (U.S. Army Engineer Waterways Experiment Station); SL-82-4. TA7.W34m no.SL-82-4

